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THE BRITISH FOSSIL ECHINODERMATA.

VOL. II, PART III.

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Palæontographical Society, 1905.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

VOLUME SECOND.

THE ASTEROIDEA.

BY

W. K. SPENCER, B.A., F.G.S.

PART THIRD.

Pages 67—90; Plates XVII—XXVI.

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of length to breadth are in the case of the interradial supero-marginal plates as 5·6 mm. is to 3·7 mm. Further, the tuberculation in this specimen may or may not extend over the whole of the abactinal area, the variations being on adjacent plates, and the abactinal gibbosity is not strongly developed. In the example figured on Pl. IX, fig. 3, the proportions of length to breadth in the case of the interradial supero-marginal plates are as 4·5 mm. is to 3·6 mm.; the granulated areas more generally stop short of the distal edge of the supero-marginal plate and the abactinal gibbosity is well pronounced. In view of these considerable variations it is difficult to refer these forms to more than one species.

3. Mitraster compactus, *Forbes*, sp. Pl. XVII, fig. 2; Pl. XXVI, figs. 3, 3 *a*, 3 *b*, 3 *c*.

Goniaster compactus, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 468.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, London, p. 333, pl. xxii, fig. 3.
Astrogonium compactum, *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 399.
Goniaster compactus, *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), p. 366, pl. xxii, fig. 3.

Specific Characters.—Outline pentagonal, slightly cycloidal. Eight supero-marginal plates on each side of the pentagon. Supero-marginal plates form a broad margin, and the breadth of each is about four times its length. Base of ultimate paired supero-marginal plate twice as long as the other, more proximal, supero-marginal plates. Ten corresponding infero-marginalia.

Material.—Only one specimen of this species is known. This formed a portion of Mr. Willett's collection and is now preserved in the Brighton Museum. It apparently escaped the observation of the late Dr. Wright, for the figure on Plate XVII is copied from that in Dixon's 'Geology of Sussex.' As this figure is slightly inaccurate I have had it redrawn and further details added on Plate XXVI.

Description.—The dorsal surface of the disc is covered with a number of small, subequal, closely-fitting plates. It is considerably sunk in the specimen known.

The supero-marginalia bounding the disc form a uniform margin 5·15 mm. broad. They are eight in number along each side, exclusive of the odd terminal or ocular plates. The six middle plates are about 1·2 mm. long. Their breadth is rather more than four times their length, a feature which distinguishes them

from *Mitraster Hunteri* and *M. rugatus*. A further distinctive feature is the size of the distal paired plate. This plate is triangular. The base of the triangle measures 2·7 mm., giving the plate twice the length of the more proximal plates. The plate is gibbous at its outer extremity as in *M. Hunteri*. All the plates are ornamented with a single or double marginal row of small spinelets. The ocular is a small conical plate barely visible in abactinal view. It fits into notches on the lower surface of the distal paired plates, and is, as usual, notched on its inferior surface for the purpose of protecting the unpaired terminal tube foot.

The median infero-marginal plates are rather longer than the corresponding members of the superior series. The first two, reckoning from the median interradial line, are 1·85 mm. long, and 8·5 mm. broad. The third is only 1·8 mm. long and not quite as broad. The fourth has approximately the same length but is subtriangular in form. The fifth is a small triangular plate. Two infero-marginals and a portion of a third are situated underneath the distal paired supero-marginal plate.

The ventro-lateralia visible are small hexagonal plates covered with a fine uniform granulation. The adambulacralia are small oblong plates. The margin of the disc is very abrupt, but the transition from infero-marginalia to the actinal surface is more gradual than that of the supero-marginalia to the upper surface. A number of small granules are irregularly distributed between the plates.

Remarks.—Unfortunately, the specimen is slightly distorted, so that the pronouncedly cycloidal appearance in the figure is partially due to the unnatural position of the marginal plates, which has brought the inferior series into the dorsal view. The supero-marginal plates appear to have been straight and the inferior series but slightly cycloidal. This, together with the large comparative size of the ultimate paired plate, would bring the species very near to the genus *Metopaster*. Forbes remarked upon the fact that it appeared to be intermediate between *Goniaster* (*Metopaster*, Sladen) *uncatus* and *Goniaster* (*Mitraster*, Sladen) *rugatus*. I have therefore considerable doubt as to the validity of the separation of these two genera.

Locality and Stratigraphical Position.—Upper Chalk of Haughton, Sussex.

Genus—COMPTONIA, *Gray*.

Gray, 1840. Annals and Magazine of Natural History, vol. vi, p. 278.
— 1866. Synopsis of Starfishes in the British Museum.

Body depressed, with produced tapering rays. Disc covered abactinally and actinally with numerous polygonal plates which possess a uniform granulation. Marginal plates numerous. Supero-marginal plates equal in number to the infero-marginals, and forming a moderately broad border to the disc. Infero-marginal plates (as well as all other plates) devoid of spines. Radialia present throughout length of ray.

This genus apparently differs from *Stellaster* only in the absence of spines on the infero-marginalia. It is thus similar to, as well as prior to *Ogmaster* (*von Martens*, 1865) and *Dorigona* (*Gray*, 1866).

1. Comptonia Comptoni, *Forbes*, sp. Pl. XVII, figs. 3, 3 *a*, and 3 *b*; Pl. XVIII, figs. 2, 2 *a*, 2 *b*, 2 *c*, 2 *d*.

Stellaster comptoni, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 476.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, pl. xxii, fig. 8, p. 335.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 408.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pl. xxii, fig. 8, p. 368, 370.

Specific Characters.—Disc large and interbrachial arcs wide, giving the disc a distinctly pentagonal appearance. Major radius rather more than twice the length of the minor radius. Arms elliptical in cross section. Large valvate pedicellariæ present.

Material.—Two specimens (the two cotypes) of this species are in existence. One (formerly in the Bowerbank Collection) displays the actinal aspect (Pl. XVII, fig. 3), and is preserved in the British Museum of Natural History (34311). The other (Pl. XVIII, fig. 2), which shows the dorsal aspect, is preserved in the Northampton Museum. This is the specimen figured in Dixon.

Description.—The large pentagonal disc is covered dorsally with numerous

small closely-fitting plates. In the radial areas these plates are polygonal and are about 1·8 mm. in diameter. In the interradial areas the plates measure only 1 mm. in diameter and are rhomboidal. All the plates are covered with a fine uniform granulation (Pl. XVIII, fig. 2 *a*). Upon very many of the plates are valvate pedicellariæ. Post-mortem changes have produced a sinking in of the plates over the interradial areas. Depressions, doubtless due to similar causes, appear in recent forms when dried, as also in *C. elegans*. I have been unable to distinguish either the madreporite or the anus.

The arms are not so much produced as in *C. elegans*.

R : r :: 62 mm. : 29 mm. in the specimen at Northampton.

R : r :: 55·6 mm. : 25·8 mm. in the British Museum (Natural History) specimen.

The width of the arms at the sixth supero-marginal (reckoning from the interradius) is 11·5 mm.

The supero-marginalia are oblong in shape. In the interradial areas they are of fairly constant size, measuring 5·2 mm. in breadth and 2 mm. in length. They diminish in size distalwards. They are eighteen in number, and often bear one or more valvate pedicellariæ. The margin is rounded and is about 8 mm. high.

The infero-marginalia are equal in number and similar in appearance to the superior series.

The actinal interradial areas are large and filled proximally with a number of small rhomboidal plates about 1·2 mm. in average breadth. The more distal plates are crowded, smaller, and polygonal in appearance. Traces of a fine granulation are visible.

The adambulacrals are a series of small oblong prominent plates. The largest are about 1·6 mm. in length and 1·2 mm. in breadth. Remains of their armature are still present. The mouth-angle plates are small and but slightly prominent. They also bear traces of armature. Valvate pedicellariæ are scattered apparently irregularly over all these various plates.

Locality and Stratigraphical Position.—Upper Greensand of Blackdown.

Remarks.—Forbes considered this species was equivalent to *Asterias Schultzii*, Roemer.[1] In this latter species, however, the superomarginalia meet across the dorsal surface of the ray, which would disprove Forbes' statement.

[1] Roemer, 'Versteinerungen des Norddeutschen Kreidegebirges,' pl. vi, fig. 21.

2. Comptonia elegans, *Gray*. Pl. XVII, figs 4 and 4*a*.

Comptonia elegans,	*Gray*, 1840. Ann. & Mag. Nat. Hist., vol. vi, p. 278.
Stellaster elegans,	*Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 476.
— —	*Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, London, p. 336, pl. xxii, fig. 9.
Comptonia elegans,	*Morris*, 1854. Catalogue of British Fossils, 2nd ed., p. 50.
— —	*Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 408.
Stellaster elegans,	*Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 369, 370, pl. xxii, fig, 9.

Specific Characters.—Disc strongly convex, covered with small polygonal plates. Actinal interradial areas large. Arms well produced, the major radius being at least three times as long as the minor radius. Interbrachial arcs paraboloid.

Material.—The specimen figured by Dixon, at that time in the Bowerbank Collection, is now preserved in the British Museum of Natural History (E. 2567). Both dorsal and ventral aspects are exposed. Another specimen showing an impression of the ventral surface exists in the Oxford University Museum.

Dixon's specimen, however, can hardly be the type, since Gray (1840) stated that the specimens described by him were in the British Museum or in the collection of the Zoological Society. Forbes (1848) refers only to specimens in the British Museum and the collection of the Marquess of Northampton. No part of the Bowerbank Collection is known to have come to the British Museum before 1865. The type specimen therefore must be either lost or still unrecognised in the national collection. Since it was never figured it could never be identified with certainty. It is therefore advisable to take the specimen E. 2567 as type.

Description.—The disc is high in the central and radial regions. In the interradial areas, however, post-mortem changes have caused a collapse of the test and the consequent production of deep triangular depressions. The plates covering the disc are minute, polygonal, and closely fitting. The centrale is the

only plate of the dorsal surface which is larger or more conspicuous than the remainder; all are covered with a minute uniform granulation of a quite characteristic appearance. The anus is almost central in position. It is surrounded by a circlet of plates, amongst which is the centrale. The madreporite is, as usual, situated in the next (clockwise) interradius, almost halfway between the centrale and the margin. It is a triangular plate, the apex of the triangle being a markedly acute angle.

The arms are well produced. R : r : : 30 mm. + : 9 mm. Their breadth at the base is 9 mm. Radialia, adradialia, and dorso-lateralia extend into the base of the arms. The dorso-lateralia soon disappear, but the adradialia persist as far as the seventh or eighth supero-marginal plate. When the adradials disappear the radialia become larger. They are at this point 1 mm. broad and 1·1 mm. long and therefore appear almost square.

The supero-marginalia are oblong plates of curiously uniform size in the portions of the specimen preserved. They are 1·6 mm. long and from 1·2 mm. to 1·3 mm. broad. The infero-marginalia are of the same length and are opposite to the supero-marginalia. In lateral view the supero-marginalia appear higher than the inferior series. Both series are ornamented with a number of small, fine granules which are uniformly distributed over their surfaces.

The ventral surface is concave. The ventro-lateral plates are rhomboidal in the region of the mouth. They become polygonal and crowded as they approach the margin. Some of these plates extend into the base of the arms. Around the edges of the plates spinelets are visible. The spines of the adambulacral plates are still present. Unfortunately, it is not possible to make out their exact distribution. The mouth-angle plates are not prominent.

There is no trace in this species of such valvate pedicellariæ as characterise *C. Comptoni*.

Remarks.—Gray compared this species with *Cœlaster*, Agassiz.[1] The rather vague diagnosis of *Cœlaster* given by Agassiz renders exact identification impossible.

Locality and Stratigraphical Position.—Upper Greensand of Blackdown. Also in the Upper Greensand at Folkestone (observed by Forbes).

[1] Agassiz, 'Annales des Sciences Naturelles,' 1837. Translated in 'Annals and Magazine of Natural History,' vol. i, 1838.

Genus—NYMPHASTER, *Sladen*, 1885. (See p. 14.)

4. Nymphaster radiatus, n. sp. Pl. XXV, figs. 1, 1 *a*, 1 *b*.

Specific Characters.—Arms very much produced. R : r : : 150 mm. : 10 mm. Supero-marginalia in contact almost the whole length of arm.

Material.—The only specimen of this species, formerly in the collection of Mr. J. Starkie Gardner, is preserved in the British Museum of Natural History (E. 375). The plates have, unfortunately, disappeared from the disc. Practically all that remains is the greater portion of one arm.

Description.—At the base of the arm the supero-marginalia are oblong. Each measures 2·8 mm. in breadth, 2 mm. in length, and 3 mm. in height. Distally these plates become almost square. They are ornamented by small granules which tend to run together transversally to the length of the arm (Pl. XXV, fig. 1), and articulations for spines and deep depressions for pedicellariæ are also present. They are about twenty-five in number. The infero-marginalia equal in number and size and oppose the supero-marginalia. Further they are about the same height in marginal view.

The breadth of the arm at the fourth supero-marginal is 6 mm.

Stratigraphical Position.—Lower Chalk. Locality uncertain.

Genus—PENTAGONASTER, *Linck*. (See p. 24.)

3. Pentagonaster robustus, n. sp. Pl. XXI, figs. 2, 2 *a*.

Specific Characters.—Disc covered with small rounded plates. Margin high. Rays short, high and robust. R : r : : 21·5 mm. : 9·9 mm. The supero-marginal plates meet along the median line throughout almost the whole length of the arm, and form a broad border to the disc. Interbrachial arcs paraboloid.

Material.—The only specimen of this species is the one here described, formerly in the Mantell collection and now preserved in the British Museum of Natural History (48085). The locality from which it was derived is stated rather

vaguely as Upper Chalk, Sussex. The specimen is somewhat imperfect, consisting only of the dorsal view of three arms and a portion of the disc.

Description.—The disc appears to have been covered on its dorsal surface by a large number of small, rounded, closely-fitting plates. Mostly they are subequal in size and have an approximate diameter of 2 mm. An uncertain number of even smaller granule-like plates exist scattered between these.

Both radialia and adradialia extend into the base of the arms, but only as far as the third supero-marginal plate, counting from the median interradial line. The arms themselves are short and high. The height of the specimen in the interradius is 9·2 mm. From this point the height gradually diminishes to the extremity of the ray, where it is 5 mm.

The supero-marginalia are about twelve in number. They form a broad margin to the disc and rays. Each supero-marginal plate is high, and is very convex dorsally. Hence every plate is very distinct. The six proximal supero-marginals diminish only slightly in size distalward along the ray. The next six, however, diminish much more rapidly. The supero-marginal nearest the interradius has the following measurements: height, 5·75 mm.; breadth, 4·5 mm.; length, 3 mm.

The ocular plate has broken away, and there is no trace of a madreporite.

The infero-marginalia alternate with the supero-marginal series. They are not so high and much squarer in appearance. They decrease in size much more rapidly than the upper series (see Pl. XXI, fig. 2 *a*). The infero-marginal plates, nearest the interradius, measure 4·5 mm. high and 3·2 mm. in length. Any ornament that may have existed has disappeared from all parts.

Locality and Stratigraphical Position.—Upper Chalk, Sussex.

4. Pentagonaster obtusus, *Forbes*, sp. Pl. XXII, figs. 1, 1 *a*, 1 *b*, 2, 2 *a*, 3 *a*, 3 *b*, 3 *c*, 3 *d*, 3 *e*, 3 *f*, 3 *g*.

Oreaster obtusus, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 468.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, London, p. 330, pl. xxi, fig. 12.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pl. xxi, fig. 12, pp. 364, 370.

Specific Characters.—Disc slightly convex. Majority of the plates covering the disc of subequal size and closely set. R : r : : 25 mm. : 12 mm. Extremities of arms obtuse. Interbrachial arcs only slightly rounded, giving the disc a distinctly pentagonal appearance.

Material.—The two extremities of the arms from which Forbes originally described the species when in the Dixon collection, are now preserved in the British Museum (Natural History). They are not on the same slab of chalk as represented by Forbes, but are and probably always have been two independent specimens, E. 5038 (Pl. XXII, figs. 3 *b*, *c*, *d*), and E. 5039 (fig. 3 *a*). More complete specimens have since been added to the collection (40400, Pl. XXII, fig. 1 *ex* J. Simmons' Coll., and 35481, Pl. XXII, fig. 2, *ex* H. W. Taylor's Coll.). Two extremities of arms are also preserved in the Brighton Museum.

Description.—The disc is high and distinctly pentagonal. At the edge of the disc the dorsal covering plates are crowded and polygonal in appearance. Towards the centre they become slightly smaller and rounded. The average diameter of these plates is 1·7 mm.

The madreporite is subcentral in position. It is about the same size as the other plates of the disc and is pentagonal in shape (Pl. XXII, fig. 1 *a*).

The arms are stoutly built. A triple row of polygonal plates enters their bases. The adradial series soon disappears, leaving the single radial series, which appears to persist until it reaches that part of the ray which is obtuse. From this point the supero-marginal plates may or may not be adjunct up to the end of the ray. Considerable variation appears to exist as to this point in the single specimen examined. The arms are distinctly obtuse in their distal half. This has given the species its name.

The supero-marginalia form a rather broad border to the disc. There are nine supero-marginals from the median interradius to the extremity of the ray. Towards the end of the ray the plates of this series become narrower, more oblong in appearance, and distinctly convex.

The infero-marginalia are equal in number and situated generally alternating with the supero-marginal series. They are distinctly square in shape, especially at the obtuse extremities of the ray. Their ornament is in some specimens not so coarse as that of the supero-marginals.

The actinal interradial areas are very distinct and are occupied by four series of ventro-lateral plates. As usual, the actinal plates near the mouth are larger and more rhomboidal than the distal plates. Ventro-lateral plates only extend throughout about a quarter of the length of the arm.

The mouth-angle plates are not prominent. The adambulacral plates possess a triple row of spines.

Dimensions.—Specimens 35,481 and 40,400.—The greatest width of the ray varies from 8·3 to 6·5 mm., and the least width from 7·2 to 5·7 mm. The superomarginal plates are 3·2 mm. broad near the interradii.

Specimen E. 5038.—Greatest width of ray 10·5 mm.

Specimen in Brighton Museum.—Greatest width of ray 9·2 mm.

Locality and Stratigraphical Position.—Upper Chalk, Lancing, Sussex, and also from the Upper Chalk of Kent.

Family—PENTACEROTIDÆ (*Gray*) *emend. Perrier*, 1884.

Phanerozonate Asteroids with unequally developed marginal plates, the superior series being frequently masked or hidden in membrane. Abactinal skeleton reticulate. Plates with large isolated tubercles, or spinelets, or granulose, or covered with membrane. Actinal interradial areas with large pavement-like plates which bear unequal-sized granules.

Genus—PENTACEROS, *Schulze*, 1760.

Pentaceros,	*Schulze*, 1760.	Betrachtung der versteinerten Seesterne und ihrer Theile, Warschau u. Dresden, p. 50.
Goniaster (pars),	*Agassiz*, 1835.	Mem. Soc. Sci. Nat. Neuchatel, t. i, p. 191.
Pentaceros,	*Gray*, 1840.	Ann. and Mag. Nat. Hist., vol. vi, p. 276.
Oreaster,	*Müller* and *Troschel*, 1842.	System der Asteriden, p. 44.

Generic Characters.—Form stellate, marginal plates conspicuous, defining the ambitus. Abactinal plates regular, with more or less definite intermediate papular areas. Prominent localised mammillated tubercles or spines present.

All the fossil species of this genus possess intermarginalia, but do not otherwise approach Sladens' genus *Pentaceropsis* which possesses this character. In view of the fact that intermarginalia may occur as a variation in unmistakable recent species of *Pentaceros* this character cannot invalidate the admission to the present genus of the species about to be described.

1. PENTACEROS BULBIFERUS, *Forbes*, sp. Pl. XX, figs. 1, 1 *a*, 1 *b*, and 1 *c*; figs. 2, 2 *a*, and 2 *b*; Pl. XXI, figs. 1, 1 *a*, 1 *b*, 3, 3 *a*, 4, 4 *a*; Pl. XXIII, figs. 2, 2 *a*.

OREASTER BULBIFERUS, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 468.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, pp. 328, 329, pl. xxiv, fig. 7.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 363, 370, pl. xxiv, fig. 7.
— — *P. H. Carpenter*, 1882. Geol. Mag., p. 12.

Specific Characters.—Disc and arms very convex. The centrale and primary interradialia large and tuberculiform. The major radius approximately twice the minor radius. Radialia of the arm conspicuous. Extremities of the arms swollen.

Material.—The specimens figured and described are all preserved in the British Museum (Natural History). E. 5040 (Pl. XXI, fig. 1), 40175 (Pl. XX, fig. 1), 48748 (Pl. XX, fig. 2), and E. 5041 (Pl. XXI, fig. 3), which were bought from J. Simmons, and 40399 (Pl. XXI, fig. 4), from the collection of E. Charlesworth, are all labelled as coming from the Upper Chalk of Bromley, Kent, which, however, seems to be an inexact dealer's locality, probably intentionally misleading. E. 5042 (Pl. XXIII, fig. 2), also bought of J. Simmons, is labelled "Upper Chalk, Charlton, Kent."

Other specimens are known in the Sedgwick Museum, Cambridge, Northampton Museum, and Brighton Museum. Specimens have also been described by Valette from the South of France.

This seems to be much the commonest as well as the most graceful of the Chalk Pentacerotidæ.

Description.—The general aspect of the plates of the disc gives this species a very characteristic appearance, for the five primary interradialia and the centrale are very prominent. They have a lobed widely-spreading base, and are swollen on the upper surface into an almost spherical form. Their weathered surfaces are pitted in a very regular manner, the pits indicating the former presence of

granules. Sometimes the granules are still present *in situ*. The pits are separated in the example figured Pl. XXI, fig. 1, on an average rather less than their own diameter apart. There may or may not be a slight margin to the plate. The centrale in a specimen R : r : : 40 : 20 measures 8·5 mm. in diameter. The primary interradialia are rather smaller, being 6·7 mm. in diameter. Radially the most conspicuous plates of the disc are the proximal radialia. They have a very characteristic appearance, their general shape reminding one of a breastplate. The remainder of the plates of the disc are of very various sizes and distributed in a fairly regular manner. The general arrangement of these plates is given in the general account at the conclusion of these volumes.

The madreporite is a conspicuous plate lying at the distal end of a primary interradial. The two neighbouring adradialia are notched for its reception.

The arms are moderately produced, the major radius being about twice the minor radius. Measurements of five specimens give the following :

R	r
40 mm.	20 mm.
35 mm.	17 mm.
50 mm.	25 mm.
50 mm.	25 mm.
50 mm.	20 mm.

At the base of each arm there are five series of plates visible on the dorsal surface—the radialia, adradialia, and supramarginalia. All the plates at the base of the arm overlap. They are of a type which may be derived from the breastplate shape mentioned above. They gradually become narrowed in length and increased in breadth until they are shaped somewhat like an inverted T (Pl. XX, fig. 2 *b*). The granulation is generally confined to the central region of each plate.

The arm about halfway along its length becomes swollen and the plates no longer overlap but are contiguous. They lose their ⊥-shaped form, become almost oblong, and at the same time rather tumid. This is especially noticeable in the case of the radialia. The form of the plates is, however, rarely absolutely regular, but one which is generally derivable from the breastplate shape.

If we examine a cross-section of the arm, we see that the base of the plates of the dorsal intermediate series is prolonged inwards (and ventralward), so that a single isolated plate appears club-shaped.

All the plates are pitted for granules except at the extreme margin.

The supero-marginal plates are from twelve to thirteen in number, the infero-marginals from thirteen to fourteen in number. The arm is very high and both

infero- and supero-marginal plates appear in dorsal view. In fact, the infero-marginal plates do not take any part in the formation of the actinal surface. This is parallelled in modern species of *Pentaceros*, e. g. *P. clavatus*. In marginal view the supero- and infero-marginals at the extremity of the ray very distinctly alternate. This alternation persists at the base of the arms, but here it is not always so obvious.

The supero-marginals are much higher than the infero-marginals, and also more oblong in shape. Both supero- and infero-marginal plates are regularly but coarsely pitted for granules.

In specimen figured on Pl. XX, fig. 1, we obtain the following measurements:

Breadth of fifth infero-marginal from the extremity of ray					.	5·8 mm.
Length	„	„	„	„	.	4 „
Breadth	„	supero-marginal	„	„	.	9·2 „
Length	„	„	„	„	.	3·9 „
Breadth	„	radialia	„	„	.	5·8 „
Length	„	„	„	„	.	4·4 „
Width of ambulacral groove					.	1·2 „

The ocular is visible in this specimen. It is about 1·6 mm. in length and breadth. The extremity is slightly pointed, and its ventral surface is hollowed out.

A ventral view is figured on Pl. XXI, fig. 1. Ventro-lateral plates extend almost to the extremity of the arms. These are, as usual, rather greater in breadth than in length. The adambulacral plates appear to be about half the length of the bordering actinal plates. Their armature consists of several rows of spinelets arranged in pairs.

A few intermarginalia are present in the interradii. They, as usual, press the supero- and infero-marginalia on to the abactinal and actinal surfaces of the disc respectively.

Locality and Stratigraphical Position.—Upper Chalk, Bromley, Kent; according to Dr. Rowe, probably from the Chislehurst caves near that locality.

Variations.—Variations occur amongst all the specimens, especially with regard to the ornamentation of the plates and the madreporite. The British Museum specimens, 48748, which occur together in a slab, are especially noteworthy, inasmuch as the lowest situated individual possesses on the disc no plate, which is bulbiform or raised conspicuously above the remainder.

2. Pentaceros Boysii, *Forbes*, sp. Pl. XXII, figs. 4, 4 *a*, 4 *b*, 4 *c*; Pl. XXIII, figs. 1, 1 *a*, 1 *b*; Pl. XXVI, figs. 2, 2 *a*, 2 *b*.

Oreaster Boysii, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 468.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 328, pl. xxi, fig. 6.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 362, 370, pl. xxi, fig. 6.

Specific Characters.—The primary radialia and interradialia are large hemispheroid punctate tubercles. R : r : : 80 mm. : 18 mm. Rays well produced, steep-sided, almost square in section, and tapering gradually to the extremity. Only a few of the plates of the disc enter the base of the arm. Supero- and infero-marginal plates adjunct, the intermarginalia being represented only by a few scattered granules.

Material.—The type specimen was said by Forbes (1848) to be in the collection of the Marquess of Northampton. The specimen figured and described in Dixon's 'Geology of Sussex' (see reference) was said by Forbes to have been "discovered by Major Boys and formed part of his interesting collection." This statement does not preclude the hypothesis that the specimen figured was also the type specimen. Neither specimen (if there were two) can now be traced. The following description is based chiefly on a specimen in the Sedgwick Museum, Cambridge (Pl. XXVI, fig. 2), which shows the actinal surface of the arms and a portion of the disc. It is supplemented by reference to a less nearly perfect specimen preserved in the British Museum of Natural History (J. Simmons' Coll., 46600), which presents views of isolated rays (Pl. XXII, fig. 4), and an isolated ray seen from the dorsal surface (Pl. XXIII, fig. 1) in the same museum (Dixon Coll., 48083).

Description.—The disc is covered with a number of rounded or irregularly-shaped plates. A circlet of large tubercles is very distinct and characteristic of the species. These tubercles are hemispherical and not so swollen as those of *P. bulbiferus*. They are smooth, and possess a fine distinct ornament, thus distinguishing them from the circlet of *P. coronatus*. Their diameter is about 8·5 mm., and they seem to be arranged radially and interradially, making a total of ten. The madreporite was figured by Forbes. It is roughly triangular in shape.

The arms are well produced. R = 80 mm. and r = 18 mm., the major radius being thus about four and a half times the minor radius. They taper gradually to the extremity. The breadth of the ray about the fourth supra-marginal plate is 6·8 mm. The height of the ray at the same spot is almost exactly the same. The rays are steep-sided, and consequently appear almost square in cross section.

The supero-marginalia are adjunct throughout almost the whole length of the ray, for only one or two single radialia enter the base of the ray. At the base of the ray they are flat and slightly rhomboidal. They possess an anterior indentation on their inner surface and are about 3·5 mm. in breadth. They gradually diminish in size distally and at the same time become distinctly swollen. They number about twenty-eight.

The infero-marginal plates are approximately of the same size and number as the supero-marginals. Both series imbricate slightly. The ornament of these plates consists of a number of fine granules in the centre, while there is a distinct margin without granulations.

Between the supero- and infero-marginal plates a few scattered granules represent a slight development of the intermarginalia.

The adambulacrals are a series of small oblong plates. They border the infero-marginals from about the eleventh supra-marginal onward. They are much worn, and but slight traces of their armature remain. About five adambulacrals occupy the same length as two infero-marginal plates. Proximally there is a single row of small plates which separate the two series.

Only a few scattered ossicles of the actinal surface of the disc remain.

Locality and Stratigraphical Position.—Upper Chalk, Kent.

Remarks.—Valette ('Bull. Soc. Yonne,' 1902) has described a number of species of starfishes from the Senonian of the South of France. The remains are found as scattered ossicles. Some of these are grouped by Valette as a new species which he calls *P. senonensis*. They are noticed by the author to resemble *P. Boysii* except that they are smooth and therefore do not have the ornament possessed by *P. Boysii*. Valette regards this absence of ornament as rendering them specifically distinct from *P. Boysii*, as other ossicles found in close proximity still possess the ornament. In view of the vagaries of the way in which solution may occur, I cannot admit this contention and consider that it is much more probable that the ossicles at one time possessed ornament and were identical with *P. Boysii*. All the other ossicles except those of the so-called *Arthraster senonensis* (*vide infra*, p. 92) were identified with English Cretaceous genera, which would support this contention.

3. Pentaceros coronatus, *Forbes*, sp. Pl. XIX, figs. 1, 1 *a*; Pl. XXIV, figs. 2, 2 *a*, 2 *b*, 2 *c*; Pl. XXV, fig. 9.

Oreaster coronatus, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 467.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, pp. 327, 328, pl. xxi, fig. 7 *a*—*d*.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 362, 370, pl. xxi, figs. 7, 7 *a*—*d*.

Specific Characters.—Disc large, with conspicuous nodular primary radialia and interradialia. The major radius is about five times the length of the minor radius. Sides of arms very steep, so that the arm appears to be square in cross section. A triple row of intermarginalia present in the interbrachial areas.

Material.—The type specimen of this species is preserved in the British Museum of Natural History (Dixon's Coll., 35480). Unfortunately, only one arm and a portion of the disc are preserved. A further specimen, registered E. 2562, from the cabinet of Mrs. Smith, of Tunbridge Wells, is preserved in the same museum, and another example is to be seen in the Museum of Practical Geology, Jermyn Street.

Description.—The most conspicuous feature of the disc is the circlet of ten "large, more or less polygonal nodose pyramidal tubercles."[1] These are the primary radialia and interradialia. The interradial tubercles are rather larger than the radial tubercles, the former measuring 9·2 mm., the latter 7·7 mm. in diameter. The remainder of the disc is covered by irregularly shaped plates.

The madreporite has been broken away from the disc of the specimen no. 35480. It is figured Plate XXV, fig. 9.

R : r : : 58 mm. : 19 + mm. in the type specimen where the single arm is broken short. In specimen no. E. 2562 R : r : : 100 mm. : 20 mm. The arms are 30 mm. broad at the base. Their surface is flat, and the sides slope away at right angles, so that a cross section of the arm is square.

Both radial and adradial plates are present in the base of the ray. The adradials are irregular in shape and soon disappear. The radials are roughly oblong in appearance, and exist throughout that portion of the arm preserved. They diminish in size, however, distally.

The supero-marginal plates are indented on their anterior median surface.

[1] Forbes, in Dixon's 'Geology of Sussex,' p. 327.

They appear to imbricate slightly at their margins. The breadth of the fourth supero-marginal is 7 mm., the length 4 mm., and the height 3·5 mm. The height of the ray at this point is 12·2 mm.

The infero-marginal plates are opposite to the supero-marginals. They are approximately about the same size and number. Between the supero- and infero-marginal series a triple series of intermarginalia occurs in the interradial areas. The inner and larger intermarginals persist throughout the greater part of the length of the arm. It is this intercalated series which gives to the arm its great proportionate depth. The outer and smaller series disappear at about the seventh and ninth infero-marginal plates.

The ornamentation of the plates appears to have been worn away, although upon many of the plates a distinct marginal area may be seen.

Upon most of the plates there occur small entrenched pedicellariæ which are very characteristic of this species of *Pentaceros*. They consist of a small pit from which radiate two fine entrenchments (see Pl. XXIV, fig. 2 *a*).

One of the rows of specimen no. E. 2562 is distorted so as to bring the ventral surface into view. This shows that the ventro-lateral plates extend well towards, and perhaps all the way to, the extremities of the arm.

Locality and Stratigraphical Position.—The locality of the type specimen is given as Lower Chalk, Washington, Sussex. The specimen registered E. 2562 is from the Lower Chalk, Burham, Kent, and the specimen in the Museum of Practical Geology is from the Lower Chalk, Dover.

Remarks.—The specimen registered E. 2562 presents only one or two pedicellariæ, which are so characteristic and numerous on the other two specimens.

4. Pentaceros squamatus, *Forbes*, sp. Pl. XXV, figs. 3, 3 *a*, 3 *b*, 3 *c*.

Oreaster squamatus, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 468.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 328, pl. xxiii, fig. 7.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 363, 370, pl. xxiii, fig. 7.

Specific Characters.—Disc high, with conspicuous primary radialia, inter-

radialia and centrale. Major radius about four times the length of the minor radius. Only radialia enter the base of the arm. Dorsal surfaces of arms flat, sides slope away at an obtuse angle from this. Ossicles distinctly imbricating. A few intermarginalia present.

Material.—The only specimen of this species is preserved in the Brighton Museum. The specimen consists of the disc and a portion of three arms. On the whole little displacement of the ossicles has taken place.

Description.—The disc is strongly convex, and is covered with the circlet of primary radialia and interradialia which are disposed around the centrale. All these ossicles appear shaped like a breast-plate. The centrale has a diameter of 4·2 mm. The primary interradialia are larger, possessing a diameter of 5·3 mm., whilst the primary radialia are the smallest of the series, measuring only 3·7 mm. across. Between the centrale and the primary interradialia a number of irregularly distributed plates appear. In the next right-hand interradius to the madreporite a number of these appear to have surrounded an anal opening. The primary interradialia almost touch one another, and the radialia consequently rest on the bases of pairs of ossicles. A few adradialia are present, but they are confined to the disc. A pair of them help to enclose the madreporite, which is a polygonal plate 9 mm. in greatest diameter. The ornamentation of the ossicles is rather coarse when present, but usually it is very much worn away.

The arms are well produced. R : r : : 30 + mm. : 7·8 mm. They are 1·3 mm. in breadth at the base. After the fourth or fifth radiale the remainder become minute but persist throughout the length of the arm preserved.

The supero-marginalia are finger-shaped; they, as also the infero-marginalia, distinctly imbricate. The dimensions of the third supero-marginal, reckoning from the median interradial line, are as follows: length 2·3 mm., breadth 3·1 mm. The long axes of the supero-marginal plates slope away distally, thus causing pairs of plates to assume the shape of arms of a V. They are at least thirteen in number.

The infero-marginal plates are similar in size and number to the supero-marginal series. In the interradii a few intermarginalia are present. These force the supero-marginal series to the surface of the disc.

Nothing is known of the ventral surface.

Locality and Stratigraphical Position.—Upper Chalk, Woolwich.

5. Pentaceros ocellatus, *Forbes*, sp. Pl. XXV, figs. 4, 4 *a*.

Oreaster ocellatus,	*Forbes*,	1848. Mem. Geol. Surv. Great Brit., vol. ii, p. 468.
—	—	*Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 329, pl. xxi, fig. 13.
—	—	*Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Echin. (Suites à Buffon), p. 389.
—	—	*Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 364, 370, pl. xxi, fig. 3.
Pentaceros	—	*McPherson, W.*, 1902. Rep. Brighton Nat. Hist. Soc.

Specific Characters.—Ventro-lateral plates (as probably also the dorsal plates) depressed and finely striated on their truncated surface so as to simulate the surface of a madreporite, with sides rugged and ocellato-punctate. Between these plates smaller ossicles of a similar character are interspersed.

Material.—But one specimen of this species was known to Forbes. This is preserved in the British Museum of Natural History (Dixon Coll., E. 2571). It is a mass of ossicles which look as if they were derived from the dorsal surface of the disc. They are more spheroidal and somewhat larger than the ossicles of the ventral surface of the more nearly perfect example discovered by Mr. William McPherson in the Senonian Marsupites band at Brighton. This he presented to the British Museum (Natural History) in 1901 (E. 5012).

Description.—The disc and arms are unknown. The specimen no. E. 5012 shows a well-preserved portion of the ventral surface. The mouth-angles were occupied by single initial rhomboidal ossicles. To these succeed the ventro-lateral ossicles which border the ambulacral groove. These are pentagonal ossicles of very uniform size. The length of the exposed sides of the ossicles bordering the groove is 4·4 mm. and the greatest breadth of an ossicle 4·2 mm. The remaining ventro-lateral plates are hexagonal, but of almost the same dimensions, although the plates appear to become a little larger distally.

The plates overlap one another considerably, rendering precise measurement difficult. Between the larger plates are interspersed large numbers of smaller and more irregular ossicles which fill up the angles between their sides. The whole test would be thus very strongly built.

Both larger and smaller plates are curiously similar in appearance. The

madreporiform striations on the truncated summits and the ocellato-punctate sides give a most characteristic appearance and render the species unmistakably distinct from all known species of *Pentaceros*.

The ambulacral groove is 3·5 mm. wide. The adambulacrals are difficult of recognition and have probably for the most part been lost, but a large number of the hour-glass shaped ambulacrals may be seen.

Locality and Stratigraphical Horizon.—Upper Chalk, Kent; Upper Senonian, Brighton.

6. Pentaceros abbreviatus, n. sp. Pl. XXIV, figs. 1, 1 *a*, 1 *b*, 1 *c*.

Specific Characters.—Body of medium size. Arms moderately produced, but their breadth making them appear stumpy, rounded at the extremities, and hemispherical in cross section. Five series of dorsal ossicles enter their base. Of these the radialia and adradialia persist throughout the length of the arm. A few small intermarginalia are present.

Material.—There is only one specimen known of this species, and of this practically all that remains are two arms. It is preserved in the British Museum of Natural History (J. Tennant's Coll., 57538).

Description.—These arms are characteristically wide, the width of the arm at the base being 31 mm. They narrow very gradually towards the extremity. Throughout the ray the ossicles, except for the differences noted below, are very similar in appearance. At the base of the ray, where dorso-lateralia also enter into the composition of the dorsal skeleton, they are rounded and possess interspaces of considerable extent. These interspaces are often filled by smaller granules arranged irregularly. At times, however, between two radialia or adradialia one of the smaller ossicles is arranged in a very regular and alternating manner. Both large and small ossicles are finely granulated, and the large ossicles alone are perforated for pedicellariæ. The average size of the larger ossicles at the base of the arms is about 6 mm. Towards the extremity of the ray the radialia, adradialia, and marginalia become hexagonal, and fit very closely so as to make a compact skeleton. The terminal ocular plate is hexagonal and conspicuous. It has a flattened articulation which undoubtedly was originally occupied by a spine. Several of the other dorsal plates in the distal portion of the ray also possess similar articulation.

The supero-marginalia and infero-marginalia are equal in number. There were probably thirteen of each in the space between an interradius and an extremity of an arm.

In the interbrachial arc there is a series of minute granular intermarginalia.

The traces of the disc which are present suggest that the ossicles of this region were oval in shape and minute in size. I exposed a portion of the ventral surface of the arm, but, unfortunately, little trace of structure was shown. The ventro-lateralia extended to the extremity of the ray. The ridges of the adambulacral armature are lost.

Locality and Stratigraphical Position.—Upper Chalk, Charlton, Kent.

7. Pentaceros bispinosus, n. sp. Pl. XXIII, figs. 3, 3 *a*, 3 *b*, 3 *c*.

Specific Characters.—Disc large. Arms moderately produced. Single isolated marginal ossicles vertebra-shaped with biconcave extremities. Ventro-lateral plates with strongly marked sockets for two or more spines.

Material.—The only specimen of this species is that preserved in the British Museum of Natural History (H. W. Taylor's Coll., 35482). Only the ventral surface is exposed, and this is very much distorted.

Description.—The disc appears to have been large. Its actinal surface is covered with a number of sub-equal oblong or polygonal plates, which possessed sockets in which fitted spines (Pl. XXIII, fig. 3*c*). These plates are 4·8 mm. long, and 3·1 mm. wide.

The arms are moderately broad, and at least four series of ventro-lateral plates enter at the base. R : r : : 60 mm. : 20 mm. (approximately), the major radius therefore measuring about three times the minor radius. The marginal ossicles are shaped very much like the centrum of a vertebra, and are biconcave. They possess a distinct granulation in their central region, which is surrounded by a wide margin. The infero-marginals at the base of the ray are about 3·2 mm. wide and 2·1 mm. long. There were probably sixteen of them from the interradius to the extremity of the ray.

The specimen is otherwise so distorted that little can be made of its structure.

Locality and Stratigraphical Position.—Upper Chalk, Sittingbourne, Kent.

The following are placed provisionally in the genus *Pentaceros* :

8. Pentaceros punctatus, n. sp. Pl. XXVI, figs. 1, 1 *a*, 1 *b*.

Specific Characters.—Body of large size. Marginal series of plates possessing well-developed foraminate pedicellariæ. Intermarginalia present.

Material.—The only example of this species is a fragmentary portion of an arm preserved in the British Museum (Natural History) and bearing the registered number E. 2561.

Description.—The body of the starfish must have been of large size. The supero-marginals are in contact in the extremity of the arm, although interspersed granular plates occur. Proximally, at least, radial plates were present. The largest supero-marginal present is 11·2 mm. high and 6·5 mm. long in its widest point. It is of rather irregular shape and possesses two foraminate pedicellariæ. The infero-marginal plates alternate with the supero-marginals. They are of the same height as the supero-marginals but only 5 mm. broad. They are oblong in shape; the two interior corners of the oblong, however, are cut away, making the ossicles six-sided. The foramina once occupied by the pedicellariæ are deep and often situated in a depression. From the foramen itself ridges may run out, which probably served for the attachment of muscles.

The infero-marginal series border only the side of the arm and take but little part in the formation of the ventral surface.

An intermarginal series of rounded granular plates occurs.

Locality and Stratigraphical Position.—Upper Chalk.

9. Pentaceros pistilliferus, *Forbes* sp. Pl. XXV, fig. 5.

Oreaster pistilliferus, *Forbes*, 1848. Mem. Geol. Surv. Great Brit., vol. ii, p. 467.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 329, pl. xxi, fig. 15.
— pistilliformis, *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 389.
— pistilliferus, *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), pp. 363, 370, pl. xxi, fig. 15.

Specific Characters.—Primary radialia (or interradialia) large with a dilated summit which possesses no ornament and is excavated into pits. "Ossicles of the arm are narrow, shuttle-shaped, tumid in the centre and slightly impressed towards each extremity" (Forbes).

Material.—Several fragmentary remains of this species are known. The most nearly perfect remains are those in the Museum of Practical Geology, Jermyn Street. Other specimens are in the British Museum (Natural History), registered E. 5037, 57624, E. 2564 (all Pl. XXV, fig. 5), 7600, E. 25637, E. 2565.

Description.—Nothing is known further than the description given in the diagnosis. Forbes' description reads as if he had described the species from the specimen in the Museum of Practical Geology. This originally was in the collection of the Marquis of Northampton. Forbes seems to have described the large ossicles upside down. He also says they were in a circlet of five, which is not apparent in any specimen known. The roughened and pitted surface recalls in some respects the primary radialia and interradialia of *P. coronatus*.

Locality and Stratigraphical Position.—Upper Chalk, Kent and Sussex.

10. Pentaceros, sp. Pl. XXV, fig. 7.

This specimen is preserved in the British Museum of Natural History (no. 5514). It consists of five marginal plates which are 12·3 mm. high, and have an average length of 5·5 mm. The plates are rugged in appearance and the ornament is worn away. A cirral of a crinoid (probably *Bourguetiocrinus*) has become fixed between two of these plates.

11. Pentaceros, sp. Pl. XXV, fig. 8.

The only specimen is preserved in the Brighton Museum. It consists of a few marginal plates. The supero-marginals are rather irregular in shape, some being almost wedge-shaped. On an average they are 4 mm. high and 3·2 mm. long. The infero-marginals are opposite and equal in length to the supero-marginals. They are only 2·9 mm. high. The plates possess a distinct margin, but the

ornament otherwise is worn away. There are a few small granular intermarginalia.

With these plates is associated a large plate which appears to be a worn radial or interradial of *P. Boysii*.

Family—ASTROPECTINIDÆ (*Gray*, 1840), *emend.* Sladen, 1886.

Phanerozonate Asteroids with large marginal plates bearing spines or spiniform papillæ. Abactinal skeleton with true columnar papillæ. Actinal interradial areas small, interradial plates when present spinose. Ambulacral plates short and more or less compressed. Superambulacral plates present. Aproctuchous. Pedicellariæ rarely present.

Genus—ASTROPECTEN, *C. F. Schulze*, 1760.

Adambulacral plates touching the infero-marginal plates along the ray. Marginal and adambulacral plate not correspondent in length and number. Supero-marginal plates more or less well developed. Marginal plates long and more or less quadrate. Superior and inferior series subequal.

Astropecten, sp. Pl. XXV, figs. 2, 2 *a*.

Material.—There is one specimen in the Sedgwick Museum at Cambridge, which looks like an *Astropecten*. It is figured on Pl. XXV, figs. 2 and 2 *a*. Practically only the marginal plates are preserved.

Description.—R : r : : 45 mm. : 15 mm. The interbrachial arcs are well rounded. The supero-marginalia are remarkably uniform in size throughout the greater portion of the ray. Their breadth is 4 mm. and length 1·7 mm. About thirty of these are present from the interradius to the extremity. At the apex of the ray these plates are adjunct. The upper surface of each plate is rounded.

The infero-marginalia are equal in size, opposite to, and, as far as one can judge, similar in appearance to, the superior series. There is a distinct groove between the two series.

Locality and Stratigraphical Position.—Upper Greensand, Blackdown (?).

PLATE XVII.

METOPASTER MANTELLI, *Forbes*, sp. (Page 38.)

From the Upper Chalk.

FIG.

1. Actinal aspect; natural size. (Coll. Brit. Mus., 40402.)
   a. Infero-marginal plate; magnified 4 diameters.

MITRASTER COMPACTUS, *Forbes*, sp. (Page 67.)

From the Upper Chalk.

2. Actinal aspect; copied from Forbes in Dixon's 'Geology of Sussex,' pl. XXII, fig. 3.

COMPTONIA COMPTONI, *Forbes*, sp. (Page 69.)

From the Upper Greensand.

3. Actinal aspect; natural size. (Coll. Brit. Mus., 34311.)
   a. Infero-marginal plate; magnified 3 diameters.
   b. Lateral view of interbrachial arc; natural size.

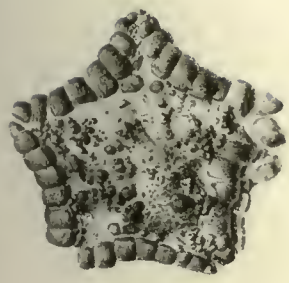
COMPTONIA ELEGANS, *Gray*. (Page 71.)

From the Upper Greensand.

4. Abactinal view; natural size. (Coll. Brit. Mus., E. 2567.)
   a. Actinal view of same specimen; natural size.

1a

1



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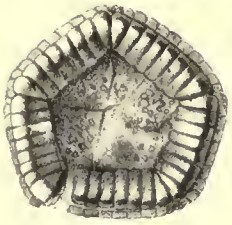

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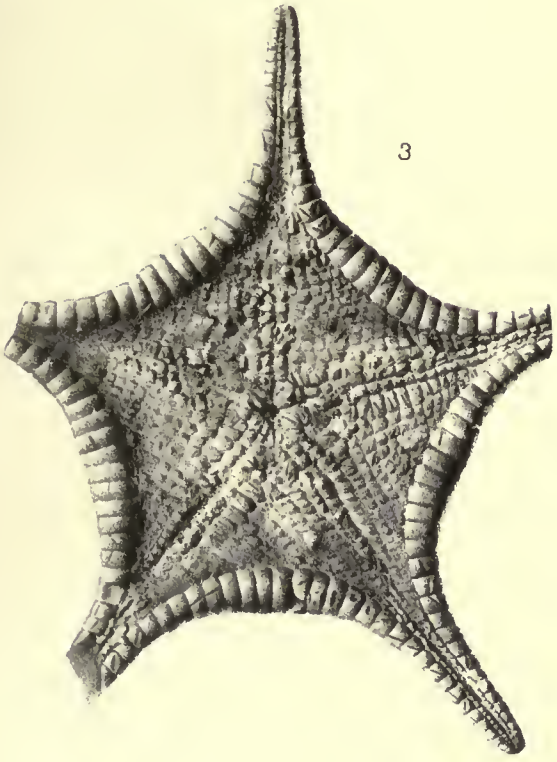

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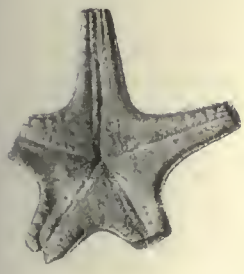

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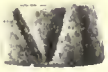

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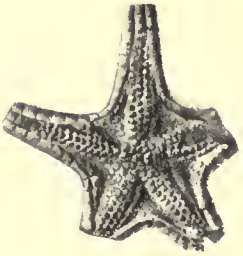


3b

A.H.Searle del. et lith.

Pitcher Ltd imp.

CRETACEOUS ASTEROIDEA .

PLATE XVIII.

ARTHRASTER DIXONI, *Forbes*. (Page 91.)

From the Lower Chalk.

FIG.

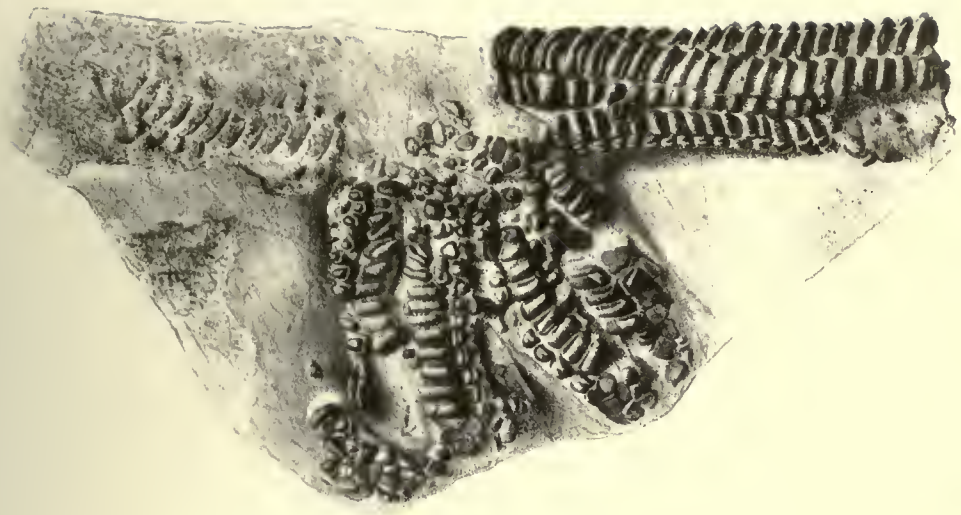
1. Actinal aspect; natural size. (Coll. Brit. Mus., 47000.)
   a. Supero-marginal plate; magnified 3 diameters.

COMPTONIA COMPTONI, *Forbes*, sp. (Page 69.)

From the Upper Greensand.

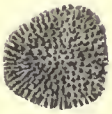
2. Abactinal view; natural size. (Coll. Northampton Mus.)
   a. Isolated plate of interradial portion of disc; magnified 6 diameters.
   b. Isolated radial; magnified 6 diameters.
   c. Lateral view of interbrachial arc; natural size.
   d. Supero-marginal plate; magnified 3 diameters.

1



1a

2a



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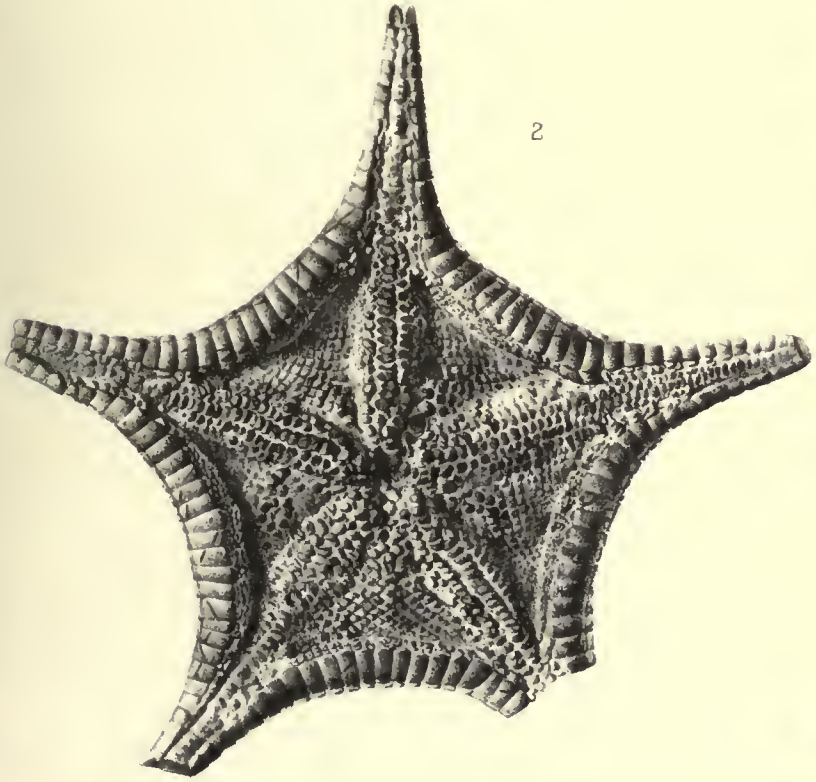

2d

2b

2c

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CRETACEOUS ASTEROIDEA .

PLATE XIX.

PENTACEROS CORONATUS, *Forbes*, sp. (Page 82).

From the Lower Chalk.

FIG.

1. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 2562.)
   a. Lateral view of arm; natural size.

METOPASTER PARKINSONI, *Forbes*, sp. (Page 31.)

From the Upper Chalk.

2. Actinal aspect; natural size. (Coll. Brit. Mus., E. 5027.)
   a. Lateral view; natural size.
   b. Ventro-lateral plate; magnified 5 diameters, showing entrenched pedicellaria.
   c. Supero-marginal plate; magnified 3 diameters.

NYMPHASTER COOMBII, *Forbes*, sp. (Page 15.)

From the Upper Greensand.

3. Actinal aspect; natural size. (Coll. Brit. Mus., 48620.)

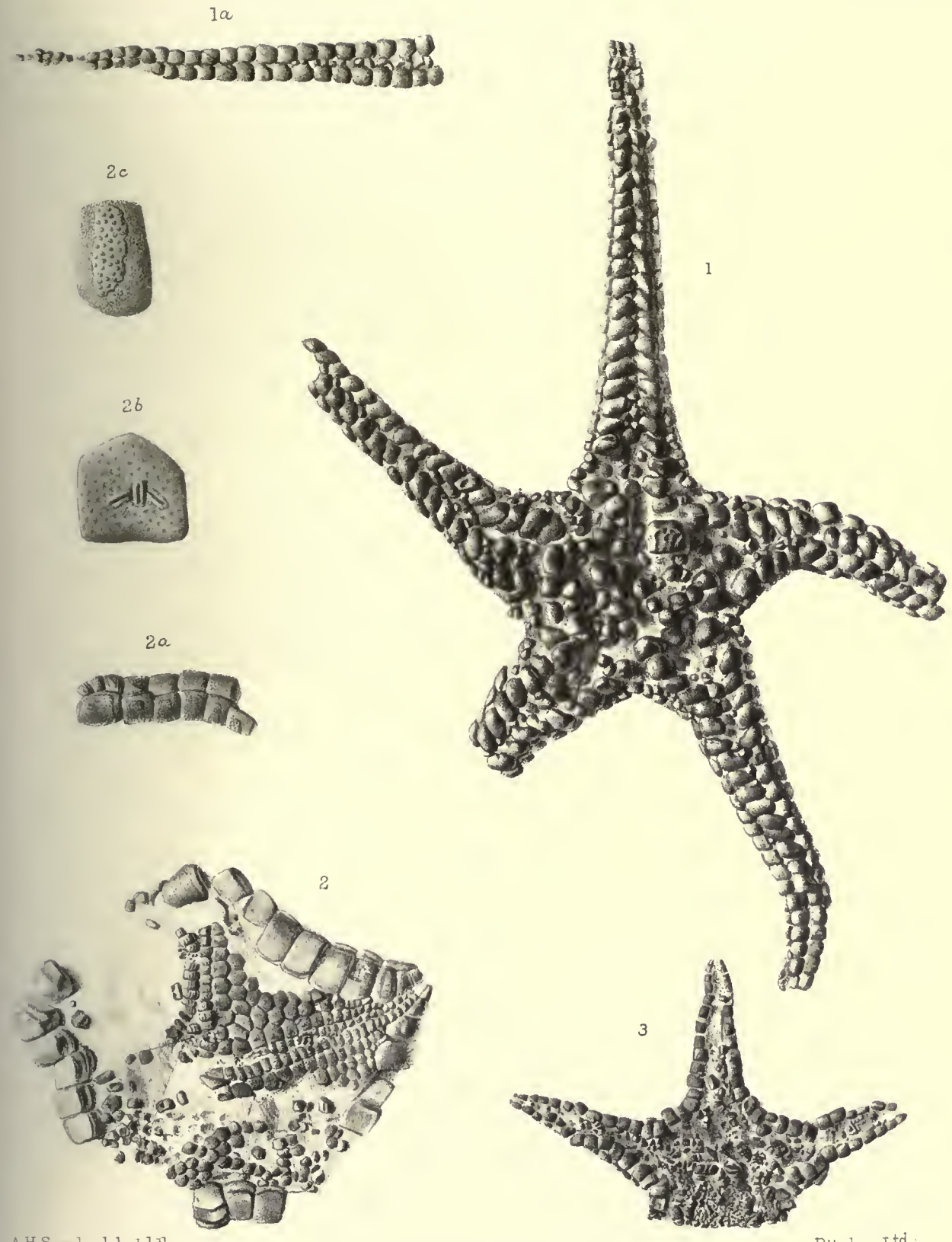

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PLATE XX.

PENTACEROS BULBIFERUS, *Forbes*, sp. (Page 77.)

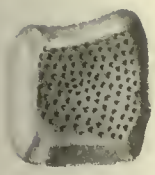
From the Upper Chalk.

FIG.

1. Abactinal view; natural size. (Coll. Brit. Mus., 40175.)
   a. Plate from dorsal part of disc; magnified 3 diameters.
   b. Supero-marginal plate; magnified 3 diameters.
   c. Plate from dorsal part of disc; magnified 2 diameters.
2. Abactinal view of two specimens; natural size. (Coll. Brit. Mus., 48748.)
   a. Madreporite; magnified 6 diameters.
   b. Proximal supero-marginal plate; magnified 4 diameters.

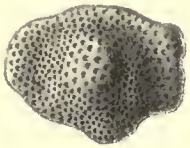
1.

1c.



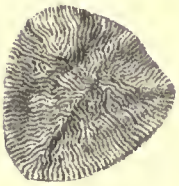
1b.

1a.



2b.

2a.



2.

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CRETACEOUS ASTEROIDEA.

PLATE XXI.

PENTACEROS BULBIFERUS, *Forbes*, sp. (Page 77.)

From the Upper Chalk.

FIG.

1. View of the extremities of three arms and portion of disc; natural size. (Coll. Brit. Mus., E. 5040.)
   a. Ventro-lateral plate; magnified 6 diameters.
   b. Actinal view of the extremities of two of the above arms; natural size.

PENTAGONASTER ROBUSTUS, n. sp. (Page 73.)

From the Upper Chalk.

2. Abactinal aspect; natural size. (Coll. Brit. Mus., 48085.)
   a. Lateral view of an arm; natural size.

PENTACEROS BULBIFERUS, *Forbes*, sp. (Page 77.)

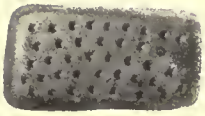
From the Upper Chalk.

3. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5041.)
   a. Madreporite; magnified 6 diameters.
4. Abactinal aspect; natural size. (Coll. Brit. Mus., 40399.)
   a. Madreporite; magnified 6 diameters.

1

1b

1a



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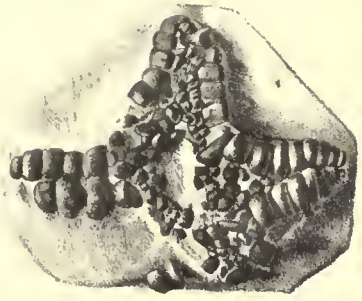
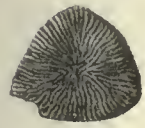


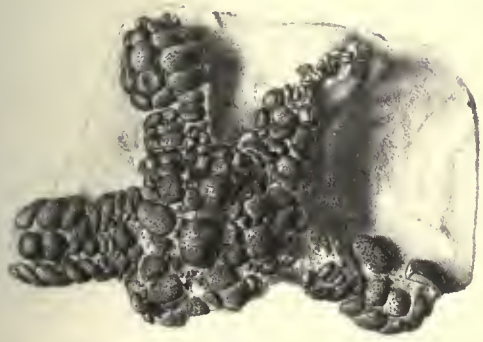
3a



4a

2a

3



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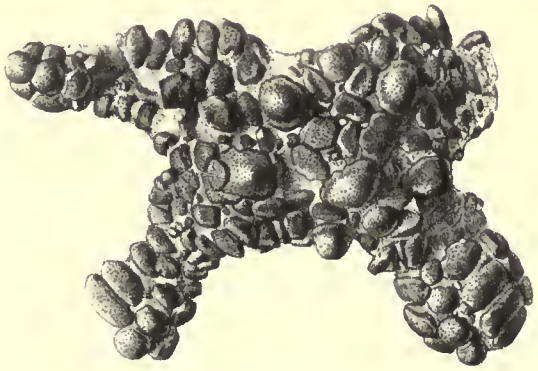

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CRETACEOUS ASTEROIDEA.

PLATE XXII.

PENTAGONASTER OBTUSUS, *Forbes*, sp. (Page 74.)

From the Upper Chalk.

FIG.

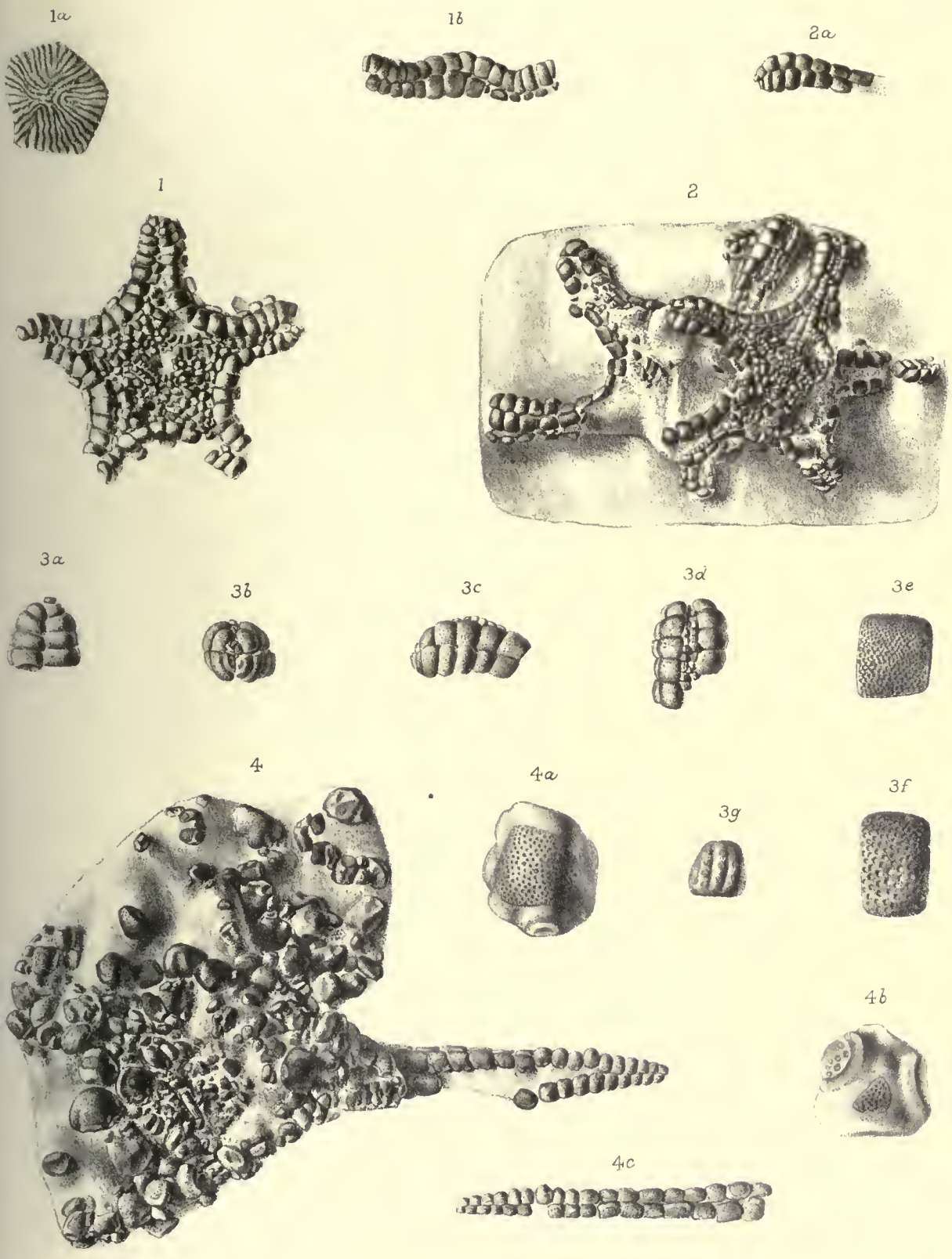
1. Abactinal aspect; natural size. (Coll. Brit. Mus., 40400.)
   a. Madreporite; magnified 10 diameters.
   b. Lateral view of margin, abactinal side upwards; natural size.
2. Actinal aspect of two specimens; natural size. (Coll. Brit. Mus., 35481.)
   a. Lateral view of extremity of arm of the underlying specimen; natural size.

3 *a*. Dorsal view of extremity of arm; natural size. (Coll. Brit. Mus., E. 5039.)
   b. End view of extremity of arm; natural size. (Coll. Brit. Mus., E. 5038.)
   c. Side view of extremity of same arm; natural size.
   d. Ventral end of extremity of same arm; natural size.
   e. Supero-marginal plate; magnified 3 diameters.
   f. Infero-marginal plate; magnified 3 diameters.
   g. Adambulacral plate; magnified 5 diameters.

PENTACEROS BOYSII, *Forbes*, sp. (Page 80.)

From the Upper Chalk.

4. Abactinal view; natural size. (Coll. Brit. Mus., 46600.)
   a. Isolated ossicle of disc; magnified 4 diameters.
   b. Isolated ossicle of disc; magnified 4 diameters.
   c. Lateral view of arm; natural size.



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CRETACEOUS ASTEROIDEA .

PLATE XXIII.

PENTACEROS BOYSII, *Forbes*, sp. (Page 80.)

From the Upper Chalk.

FIG.

1. Supero-marginal plate; magnified 4 diameters. (Coll. Brit. Mus., 48083.)
   a. Lateral view of extremity of arm from which the above supero-marginal plate was drawn; natural size.
   b. Dorsal view of extremity of same arm; natural size.

PENTACEROS BULBIFERUS, *Forbes*, sp. (Page 77.)

From the Upper Chalk.

2. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5042.)
   a. Madreporite; magnified 5 diameters.

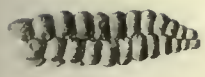
PENTACEROS BISPINOSUS, n. sp. (Page 87.)

From the Upper Chalk.

3. Actinal aspect; natural size. (Coll. Brit. Mus., 35482.)
   a. Actinal view of extremity of arm; natural size.
   b. Infero-marginal plate; magnified 3 diameters.
   c. Ventro-lateral plate; magnified 4 diameters.

1

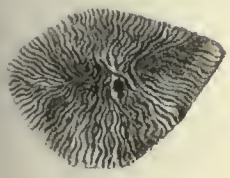
1b



1a

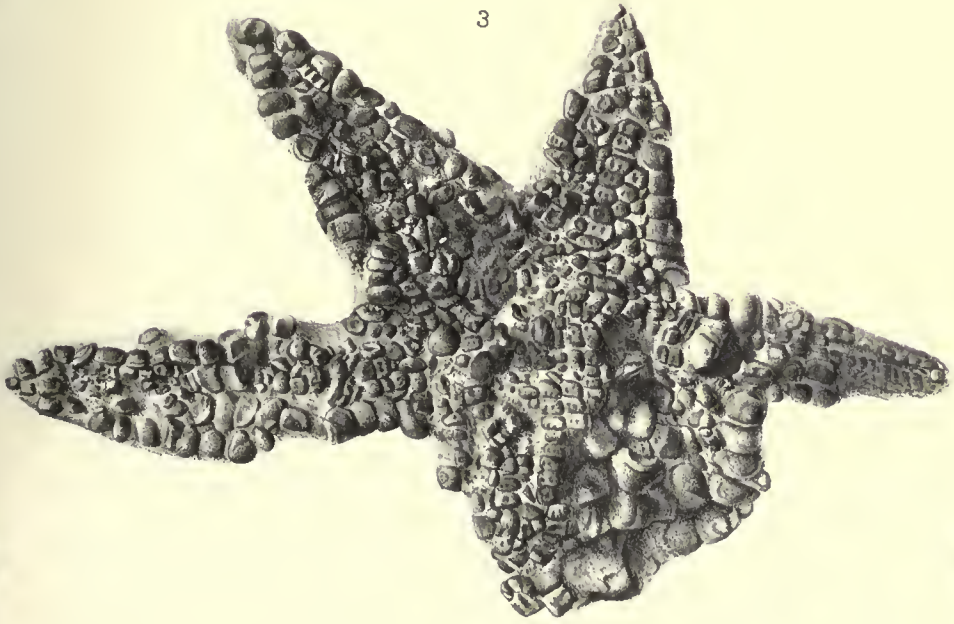
2

2a



3a

3



3c

3b

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PLATE XXIV.

PENTACEROS ABBREVIATUS, n. sp. (Page 86.)

From the Upper Chalk.

FIG.

1. Abactinal aspect; natural size. (Coll. Brit. Mus., 57538.)
   a. Lateral view of arm; natural size.
   b. Radial plate; magnified 3 diameters.
   c. Two succeeding supero-marginal plates; magnified 3 diameters.

PENTACEROS CORONATUS, *Forbes*, sp. (Page 82.)

From the Lower Chalk.

2. Abactinal aspect; natural size. (Coll. Brit. Mus., 35480.)
   a. Plate of disc; magnified 3 diameters.
   b. Supero-marginal plate; magnified 3 diameters.
   c. Lateral view of arm; natural size.

[See also Pl. XXV, fig. 9.]

1

1b

1c

2c

1a

2

2b

2a

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Pitcher Lith imp

CRETACEOUS ASTEROIDEA.

PLATE XXV.

NYMPHASTER RADIATUS, n. sp. (Page 73.)

From the Lower Chalk.

FIG.

1. Abactinal view; natural size. (Coll. Brit. Mus., E. 375.)
   a. Lateral view of margin; natural size.
   b. Supero-marginal ossicle; magnified 4 diameters.

ASTROPECTEN? n. sp. (Page 90.)

From the Upper Greensand.

2. Abactinal view; natural size. (Coll. Sedgwick Museum, Cambridge.)
   a. Isolated marginal ossicle; magnified 4 diameters.

PENTACEROS SQUAMATUS, *Forbes*, sp. (Page 83.)

From the Upper Chalk.

3. Abactinal view; natural size. (Willett Coll., Brighton Mus.)
   a. Madreporite; magnified 6 diameters.
   b. Marginal view of arm; natural size.
   c. Supero-marginal ossicle; magnified 6 diameters.

PENTACEROS OCELLATUS, *Forbes*, sp. (Page 85.)

From the Upper Chalk.

4. Actinal view; natural size. (Coll. Brit. Mus., E. 5012).
   a. Ventro-lateral ossicle; magnified 4 diameters.

PENTACEROS PISTILLIFERUS, *Forbes*, sp. (Page 88.)

From the Upper Chalk.

5. Ossicles of disc; natural size. (Coll. Brit. Mus.; from left to right the register numbers are E. 5037, 57634, E. 2564.)

GENUS? sp.? (Page 93.)

From the Chalk.

6. Ossicles; natural size. (Coll. Brit. Mus.)
   a. Isolated ossicle; magnified 4 diameters.

PENTACEROS? n. sp. (Page 89.)

From the Chalk.

7. Marginal view of ossicles of arm; natural size. (Coll. Brit. Mus., 5514.)

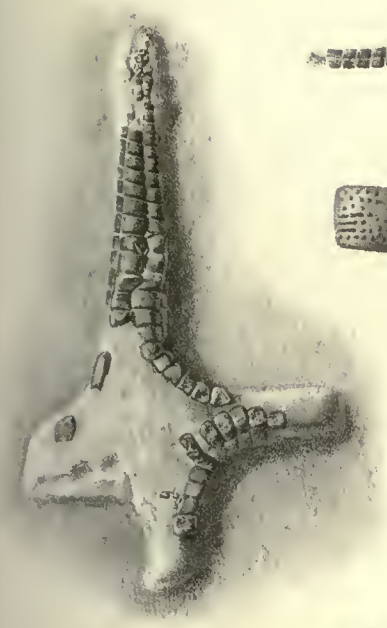
PENTACEROS? n. sp. (Page 89.)

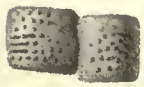
From the Chalk.

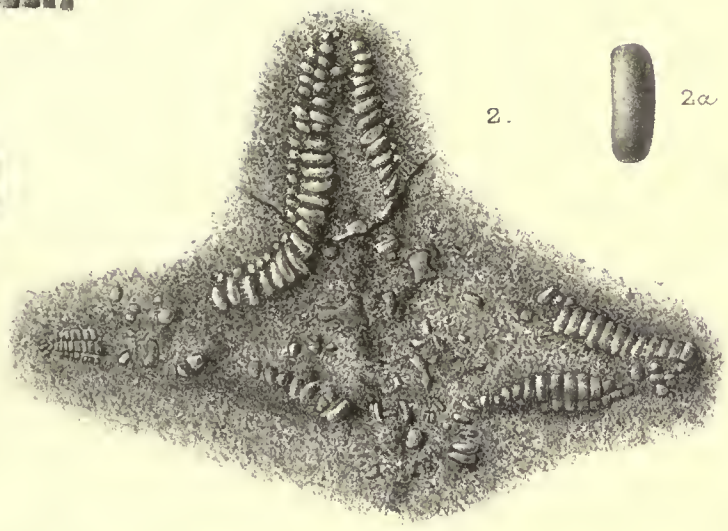
8. Marginal view of ossicles; natural size. (Willett Coll., Brighton Mus.)

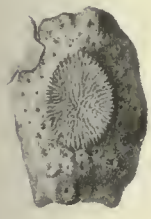
PENTACEROS CORONATUS, *Forbes* sp. (Page 82.)

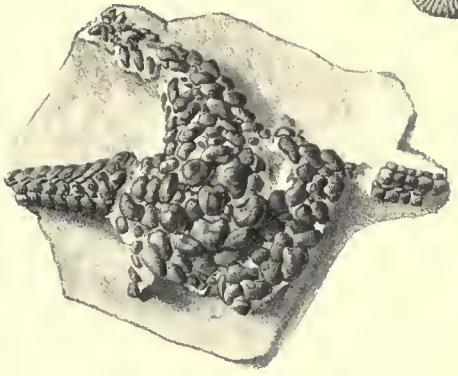
9. Madreporite; magnified 4 diameters. (Coll. Brit. Mus., 35480.)

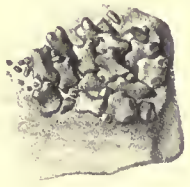












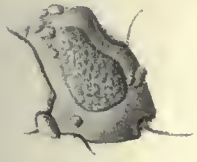


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PLATE XXVI.

PENTACEROS PUNCTATUS, n. sp. (Page 88.)

From the Upper Chalk.

FIG.

1. Abactinal view of remains of arms; natural size. (Coll. Brit. Mus., E. 2561.)
   a. Lateral view of margin; natural size.
   b. Enlarged view of single ossicle; magnified 2 diameters.

PENTACEROS BOYSII, *Forbes*, sp. (Page 80.)

From the Upper Chalk.

2. Actinal view; natural size. (Coll. Sedgwick Mus., Cambridge.)
   a. Lateral view of margin; natural size.
   b. View of isolated ossicle; magnified 4 diameters.

MITRASTER COMPACTUS, *Forbes*, sp. (Page 67.)

From the Upper Chalk.

3. Abactinal view; natural size. (Willett Coll., Brighton Mus.)
   a. View of end of arm; magnified 4 diameters.
   b. Lateral view of supero-marginal ossicles; magnified 4 diameters.
   c. Lateral view of infero-marginal ossicles; magnified 4 diameters.

CALLIDERMA MOSAICUM, *Forbes*, sp. (Page 9.)

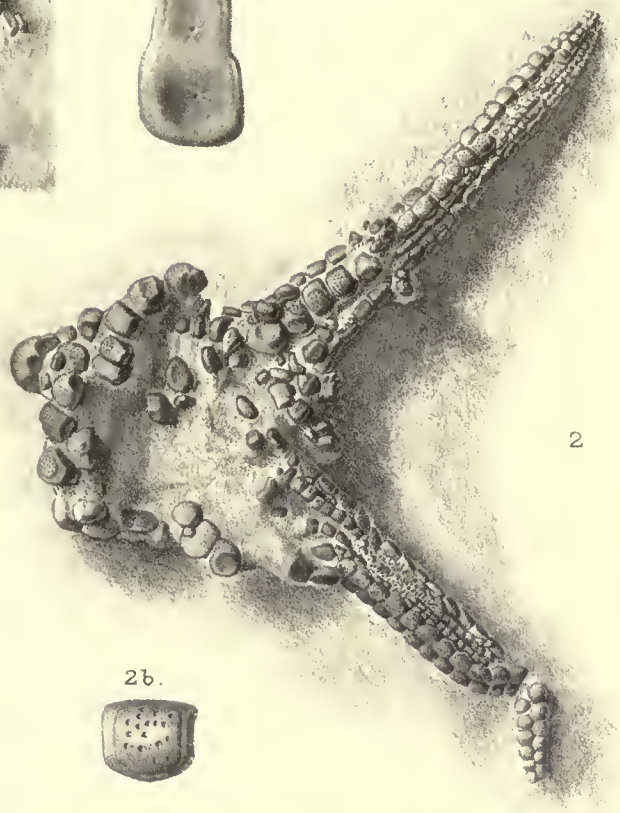
From the Lower Chalk.

4. Actinal view of ambulacral groove; magnified 4 diameters. (Coll. Sedgwick Museum, Cambridge.)
   a. Actinal view; natural size.
   b. Infero-marginal ossicle; magnified 4 diameters.

1.

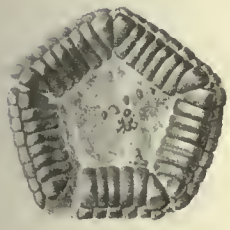
1a.

1b.



2

3.

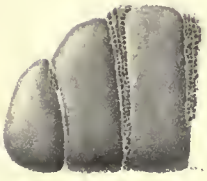


3a.

2b.

3b.

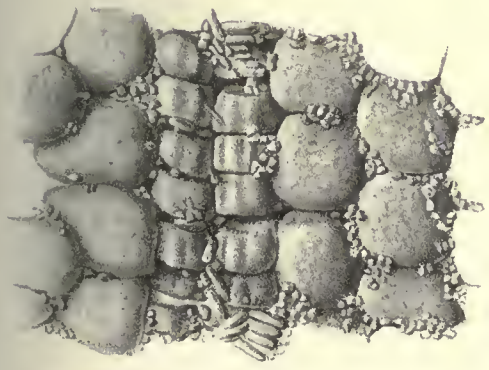
3c.



2a.

4a.

4.



4b.

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CRETACEOUS ASTEROIDEA.

THE BRITISH FOSSIL ECHINODERMATA.

VOL. II, PART IV.

PAGES 91—132; PLATES XXVII—XXIX.

Vol 61 294

Palæontographical Society, 1907.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

VOLUME SECOND.

THE ASTEROIDEA AND OPHIUROIDEA.

BY

W. K. SPENCER, B.A., F.G.S.

PART FOURTH.

Pages 91—132; Plates XXVII—XXIX.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1907.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

FAMILY UNCERTAIN.

Genus—ARTHRASTER, *Forbes*, 1848.

Arms stout and long. Radialia, marginalia, and ventro-lateralia form an alternating series of seven very completely articulating similar ossicles, which fit so closely as to leave no conspicuous interstices. Each ossicle consists of an oblong and flattened base with a surmounting ridge. Ventro-lateral plates on actinal surface of disc small and mammiform. Ossicles on abactinal surface of disc hemispheroid with a crenulated edge. All the ossicles possess, as ornament, hemispherical granular prominences.

1. ARTHRASTER DIXONI, *Forbes*. Pl. XVIII, figs. 1 and 1 *a*; Pl. XXIX, figs. 11 and 11 *a*.

ARTHRASTER DIXONI, *Forbes*, 1848. Mem. Geol. Surv. Gt. Brit., vol. ii, p. 467.
— — *Forbes*, 1850. In Dixon's Geology of Sussex, p. 336, pl. xxiii, fig. 1.
— — *Dujardin et Hupé*, 1862. Hist. Nat. Zooph. Échin. (Suites à Buffon), p. 437.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new ed., Jones), pp. 369 and 370, pl. xxiii, fig. 1.

Specific Characters.—Dorsal ridge of all of the arm ossicles well rounded. No spines present except on the adambulacral plates.

Material.—The best example of this very peculiar starfish is preserved in the British Museum of Natural History, Dixon Coll., 47000. The specimen consists of the remains of four arms, only one of which is at all well preserved. It is the type described by Forbes, and is figured in this Monograph on Pl. XVIII. A well-preserved fragment of an arm is also in the possession of Dr. Rowe, of Margate. I have referred two fragmentary specimens presented to the British Museum (E 5023 and E 5024) by Mr. W. McPherson, F.G.S., to this species (*vide infra*).

Description.—A section of the arm is similar at all points. It shows seven ossicles, namely, a radial, the pairs of supero- and infero-marginalia, and a pair of ventro-lateralia. These ossicles all alternate in series, and they closely fit the corresponding neighbouring plates in their respective series. The edges of the plates possess articulations which assist in forming this close union. All the plates

are generally similar in appearance. They differ, however, in measurements as detailed below.

Breadth of radialia	8·2 mm.
Length „ „	3·5 „
Breadth of supero-marginalia . . .	6·2 „
Length „ „ . . .	3·5 „
Breadth of infero-marginalia . . .	5·9 „
Length „ „ . . .	3·5 „
Breadth of ventro-lateralia . . .	4·5 „
Length „ „ . . .	3·5 „

It will thus be seen that the breadth of the plates diminishes as we proceed ventralwards. The ridges, also, on the plates, become more rounded in the same direction.

The ornament of the plates consists of hemispherical granular prominences of moderate size. They appear to have been especially prominent at the base of the ridge. No spine-pits are present.

The height of the ray is 16·5 mm., and the breadth is about the same. Post-mortem contraction has brought the ventro-lateralia of opposite sides into close approximation, in some cases totally obliterating the ambulacral groove. Along one or two of the arms some of the adambulacrals are still visible. They are 1·8 mm. broad and 1·2 mm. long. The portion of the plate nearest the ambulacral groove is depressed, giving the plate a two-storied appearance.

A few robust, rhomboidal, smallish ventro-lateralia are present at the base of the arm. Their breadth is 1·8 mm. They are mammiform. A few similar plates also enter the base of the arm.

The two collections of isolated ossicles presented by Mr. McPherson referred to above are very interesting. Each specimen consists of a single ossicle simulating one of the abactinal bulbiform ossicles of *Pentaceros*, but possessing the distinct *Arthraster* ornament, associated with plates which exactly match the ventro-lateralia of *A. Dixoni* and other plates which resemble the arm plates of this species except that the surmounting ridge is not so high. There is no doubt that the plates are those of a species of *Arthraster*. I have little hesitation, in spite of their occurrence in the Upper Chalk, in referring the ossicles to *A. Dixoni*, especially as it is a matter of common experience that species of Chalk starfish have a wide stratigraphical range.

Locality and Stratigraphical Position.—Forbes' type is from the Lower Chalk, Balcombe, Sussex. The specimen in the possession of Dr. Rowe was collected in the zone of *Terebratulina gracilis* in Devon. The specimens presented to the British Museum by Mr. McPherson are from the *Marsupites* zone, Brighton.

Remarks.—Forbes compared the genus *Arthraster* with the modern genus *Ophidiaster*. The larger amount of material known since that time does not allow us to recognise such affinity.

Valette (see above, p. 81) has described certain isolated plates, which are similar in form and size, as belonging to the genus *Arthraster*, and has called the species *A. senonensis*. These plates are smooth and show no trace of the surmounting longitudinal ridge or ornament which is so characteristic of *Arthraster*. Dom Aurélien Valette kindly lent these plates to Dr. Bather in order that I might examine them. I am therefore enabled to state that the plates are those of *Pycinaster angustatus*.

2. Arthraster cristatus, n. sp. Pl. XXIX, figs. 10, 10 *a*, 10 *b*.

Specific Characters.—Ridges of the radialia and supero-marginalia cristate. Upper surface of the ridge of all arm-ossicles possessing lipped pits formerly occupied by small spines.

Material.—The specimen figured on Pl. XXIX was restored by Dr. Blackmore, of Salisbury, from a number of isolated ossicles in his collection which were found in a single mass of chalk. These ossicles are the only material known of the species.

Description.—The dimensions of the ossicles are as follow:

Breadth of radialia . . .	5·4 mm.
Length „ „ . . .	3·2 „
Breadth of supero-marginalia . .	4·8 „
Length „ „ . .	3·2 „
Breadth of infero-marginalia . .	4·2 „
Length „ „ . .	3·2 „
Breadth of ventro-lateralia . .	3·8 „
Length „ „ . .	3·2 „

Just as in *A. Dixoni* the breadth of the plates diminishes ventralwards, and the ridges on the plates become more rounded in the same direction. The cristate ridges of the more dorsal plates are, however, very characteristic of the species, as are also the lipped pits on the summit of the ridges. The pits were formerly occupied by small spines. The base of the ridges of the plates possesses the granular hemispherical prominences, such as are also met with in *A. Dixoni* and characterise the genus.

Locality and Stratigraphical Position.—Micheldever, Hants. Zone of *Micraster cor-anguinum*.

ADDENDUM (to *Phanerozonate Asteroids*).

Further investigation, as a result of the privilege of investigating the fine collection of Chalk Asteroids in the possession of Dr. Blackmore, of Salisbury, has enabled me to describe several new species belonging to genera which have been dealt with in previous pages. Some of these species had been recognised but not described by Dr. Blackmore, to whom I am indebted for very many valuable suggestions.

Family—PENTAGONASTERIDÆ, *Perrier*, 1884. (See p. 3.)

Genus—NYMPHASTER, *Sladen*, 1885. (See p. 14.)

5. Nymphaster rugosus, n. sp. Pl. XXIX, figs. 7, 7 *a*.

Specific Characters.—All marginalia covered with granular prominences, which are closely crowded, and in no case arranged in a linear series. No spine-pits on the marginalia. Margin of disc lunate.

Material.—Two specimens are known of this species. They are preserved in the British Museum (Nat. Hist.), and bear the registered numbers 57516 (purchased of W. Griffiths) and 76002 (Capron Coll.). Both specimens are imperfect. The first-named specimen is figured Pl. XXIX, fig. 7, and is taken as the type.

Description.—The two specimens show the disc to have been small. The minor radius in the specimen 57516 measures about 11 mm. The arms are broken off short in both specimens, and therefore it is not possible to give the major radius.

There are about eight infero-marginalia in each interbrachial arc. These are all approximately equal in size, being 2·7 mm. long and 1·8 mm. broad. In shape they are oblong.

The margin of the disc is lunate. It is this character and the character of the granular prominences which distinguish the species from *N. radiatus*.

Locality and Stratigraphical Position.—Lower Chalk, Dover and Folkestone.

Genus—PYCINASTER,[1] nom. nov.

PYCNASTER, *Sladen*, 1891 (see p. 21), non *Pomel*, 1883. Classif. méthod. Echin., p. 42.

1. PYCINASTER ANGUSTATUS, *Sladen* sp. (see p. 21). Pl. IX, figs. 1 *a*, 1 *b*; Pl. XXI, figs. 2, 2*a*; Pl. XXV, fig. 7; Pl. XXVI, figs. 4, 4 *a*, 4 *b*.

This species appears to be quite common in the Upper Chalk. An exceedingly well-preserved specimen is in the collection of Dr. Blackmore, of Salisbury.

The following specimens, which belong to the genus *Pycinaster*, and probably to this species, have been erroneously ascribed by me to other genera and species in Part III of this volume (pp. 67–90).

The single specimen described on p. 73 as a new species, *Pentagonaster robustus*, is probably an immature form of this species. A collection of five ossicles described (p. 89) as *Pentaceros*, sp., and the specimen figured on Pl. XXVI as *Calliderma mosaicum*, also belong to the species. The latter specimen should be described as from the Upper Chalk.

Dom Aurélien Valette has courteously enabled me to examine the syn-types of his *Arthraster senonensis* ('Bull. Soc. Sci. Yonne,' 1902, p. 23). They prove to be marginals of *Pycinaster angustatus*. Four ossicles referred by him to his *Pentaceros senonensis* (*vide infra*) also belong to the present species.

2. PYCINASTER SENONENSIS, *Valette*, sp. Pl. XXVI, figs. 1, 1 *a*, 1 *b*; Pl. XXIX, figs. 6, 6 *a*.

PENTACEROS SENONENSIS, *Valette*, 1902. Bull. Soc. Sci. Yonne, vol. lvi, pp. 17, 18, figs. 1, 2 (non 3—7).

— PUNCTATUS, *Spencer*, 1905. Antea, p. 88.

Dr. Blackmore's material enables me definitely to ascribe this species to *Pycinaster*, and to add the following new diagnosis and details:

Specific Characters.—Body of large size. Breadth of marginalia more than twice their thickness. All marginalia smooth or with very shallow hexagonal spine-pits.

Description.—The marginalia may be as much as 20 mm. high. They appear to be distinguished from the marginalia of *P. angustatus*, not only by their

[1] Πυκινός, compact, Homeric form of πυκνός. Dom Aurélien Valette kindly pointed out the prior use of *Pycnaster* to Dr. F. A. Bather, who suggests the above emendation.

magnitude, but also by the manner in which the upper surface is turned over so as to make the ossicle ſ-shaped (compare Text-fig. 23, p. 119).

Associated with these marginalia are found rounded, smooth ossicles, which are correspondingly large, being as much as 12 mm. in diameter, and which are undoubtedly ossicles from the abactinal surface of the disc. Their size and form (see Pl. XXIX, fig. 6) render them liable to be mistaken for ossicles of *Stauranderaster* (see p. 125). They do not, however, possess spine-pits, and species of *Stauranderaster* which do not possess spine-pits are very distinct, having nodular abactinal ossicles of a very characteristic appearance (compare *S. coronatus*, Pl. XXIV, fig. 2). There appears therefore to be no doubt that these ossicles should be referred to the genus *Pycinaster*, and probably to *P. punctatus*. The base of the abactinal ossicles of *P. angustatus* is produced, as also in *P. crassus* (Pl. XXIX, fig. 4 *a*), and quite different from the flattened base of these ossicles.

Remarks.—It might be urged that the differences which separate these ossicles from those ascribed to *P. angustatus*, are not sufficient warrant for a new species. I regard the differences, however, given above as important, and though several well-preserved specimens of *P. angustatus* are known, none approaches the large size which *P. punctatus* must have attained. On p. 81, *Pentaceros senonensis*, Valette, was regarded as probably identical with *P. Boysii*. Examination of the original specimens, which I owe to the courtesy of Dom Aurélien, shows that they belong to four different species: *Stauranderaster coronatus*, *S. argus*, *Pycinaster angustatus*, and my "*Pentaceros punctatus*." The last species is represented by two dorsal ossicles from Les Clérimois (figs. 1 and 2). With the concurrence of Dom Aurélien, I therefore take the original of his fig. 1 as type.

Locality and Stratigraphical Position.—The specimens in the possession of Dr. Blackmore are from East Harnham, Wilts., zone of *Actinocamax quadratus*.

3. Pycinaster crassus, n. sp. Pl. XXIX, figs. 1, 2, 2 *a*, 3, 3 *a*, 4, 4 *a*, 5.

Specific Characters.—Body of large size. Height of marginalia not twice their thickness. Median marginalia smooth. More distal marginalia with prominent mammilations.

Material.—There are about eight fragmentary specimens of this species in the British Museum (Nat. Hist.). The specimen registered E. 2576 (Mantell Coll.) shows considerable portions of the actinal surface, and that registered 35498 (Taylor Coll.) the dorsal view of a well-preserved portion of one arm. Both these are figured on Pl. XXIX. Another specimen, registered E. 2628 (Mantell Coll.), shows a portion of the abactinal surface of the disc. The other specimens are

mostly collections of isolated plates. The specimen registered 35498 is taken as the type.

Description.—The abactinal surface of the disc appears to have been covered with a number of plates of generally uniform size, with an average diameter of about 3·8 mm. A few plates exceed this size, but in no case are they as large as the corresponding plates in *P. punctatus*.

No specimen is sufficiently well preserved to give the proportionate lengths of the major and minor radii, but there is no doubt that the arms were considerably produced. A row of hexagonal tabulate radialia are present throughout the greater portion of the arm. The breadth of the arm at the base in the specimen registered E. 2576 is about 22 mm. This specimen, however, judging by the dimensions of the marginal plates, does not by any means appear to have attained the usual size of the species. The length of its minor radius is 18·5 mm.

The median supero-marginalia are quite smooth and are distinguished from those of all other species of the genus by their thickness (Text-fig. 24 *a*). In full-grown specimens they appear to be 18 mm. in breadth, 6 mm. in length, and 10 mm. in thickness. More distally the supero-marginalia acquire large mammilate rugosities.

The infero-marginalia are similar in character to the superior series.

Two rows of ventro-lateralia enter the base of the arm. Most of the ventro-lateralia appear to have been rhomboidal in shape and of uniform size. They possess very shallow hexagonal fittings indicating the former possession of granules.

Locality and Stratigraphical Position.—Upper Chalk, Kent.

Genus—METOPASTER, *Sladen.* (See p. 30.)

9. METOPASTER QUADRATUS, n. sp. Text-figs. 1, 2, p. 98.

Specific Characters.—Marginal plates in interbrachial areas almost square. Raised area on marginal plates without spine-pits. Supero-marginal plates rugose on interior surface. Ultimate supero-marginal plates may or may not be the largest of the series, variation in this respect being especially marked. Abactinal plates of disc with distinct stellate marking.

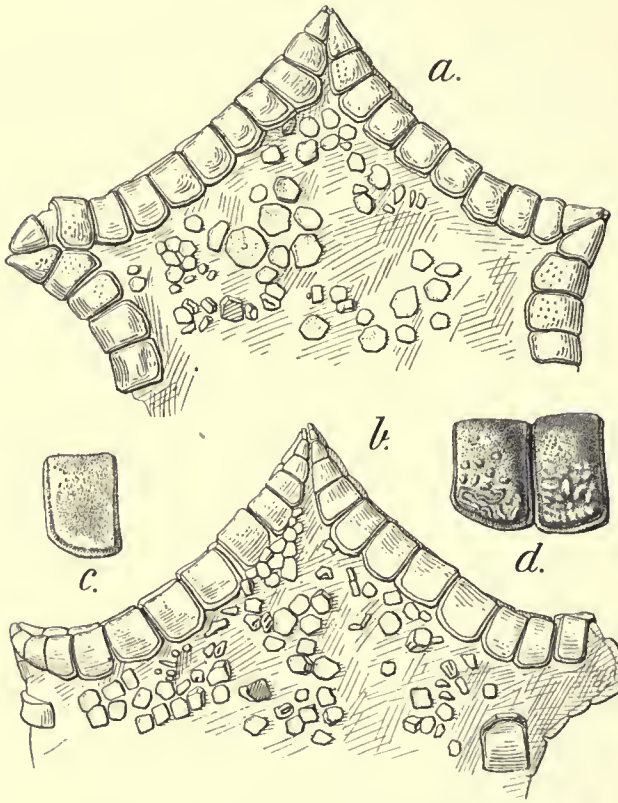
Material.—There are three fairly perfect and four fragmentary specimens of this species in the collection of Dr. Blackmore, of Salisbury. Two of these are figured in Text-figs. 1, 2. The species was discovered by Dr. Blackmore, who suggested the specific name "*quadratus*" on account of the characteristic shape

of the majority of the marginal plates. The type is the specimen figured in Text-fig. 2.

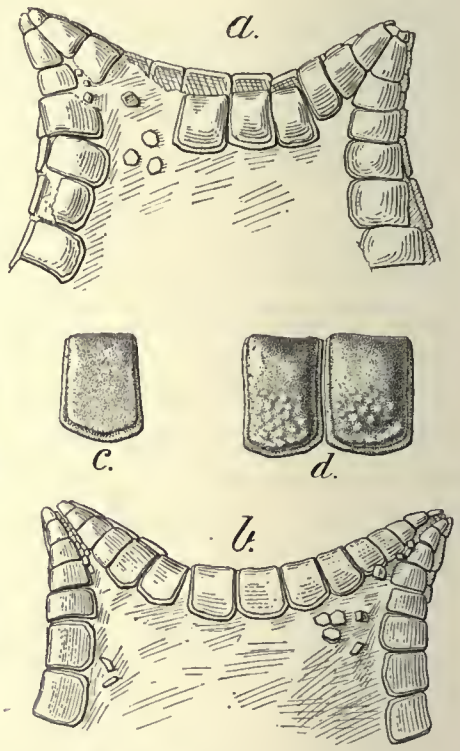
Description.—The abactinal area of the disc is covered with hexagonal plates, which have a distinctly stellate appearance on their upper surface.

The arms are distinctly produced. In the specimen figured in Text-fig. 1, R : r : : 41 mm. : 28 mm. In the specimen figured in Text-fig. 2, R : r : : 41 mm. :

TEXT-FIG. 1.



TEXT-FIG. 2.



TEXT-FIG. 1.—*a*, Abactinal view of a specimen of *M. quadratus*, nat. size; *b*, actinal view of the same specimen; *c*, view of infero-marginal plate magnified two diameters; *d*, view of two supero-marginal plates magnified two diameters.

TEXT-FIG. 2.—*a*, Abactinal view of another specimen of *M. quadratus*, nat. size; *b*, actinal view of the same specimen; *c*, view of infero-marginal plate magnified two diameters; *d*, view of two supero-marginal plates magnified two diameters.

30 mm. The length of the side in the first-named specimen is 51 mm., in the second-named specimen 56 mm.

The supero-marginalia are either five or six in number, counting from the median inter-radial line to the extremity of the arm. In the inter-brachial area they are distinctly quadrate in character, and are from 7 to 8 mm. in width and from 6 to 7 mm. long.

The terminal paired supero-marginalia present very curious features. In the specimen figured in Text-fig. 1 some of these plates are large and tri-

angular, just as in a typical *Metopaster*. Other terminal plates are, however, small and approximate to those characteristic generally of *Asteroidea*. The specimen figured in Text-fig. 2 presents no terminal plate which has a resemblance to those typical of *Metopaster*. In all other respects the specimens are almost exactly similar to one another.

The infero-marginalia are smooth and slightly concave in the centre. They are eight in number.

The actinal area of the disc is covered with sub-equal plates, which are four-sided in the inter-radial regions and tend to become hexagonal radially.

Locality and Stratigraphical Position.—Zone of *Actinocamax quadratus*, East Harnham, Salisbury.

Remarks.—The ornament of this species is identical with that of *M. uncatus*. The important differences between the species lie in the shape of the marginal plates, the character of the terminal supero-marginalia which show their especial peculiarities in all the specimens, and the ornament of the abactinal plates of the disc.

Family—PENTACEROTIDÆ (*Gray*), *emend. Perrier*, 1884. (See p. 76.)

Genus—STAURANDERASTER, novum. (See p. 125.)

12. S. ARGUS, n. sp. Pl. XXV, figs. 6, 6 *a*; Pl. XXIX, figs. 8, 8 *a*, 9, 9 *a*.

Specific Characters.—Ossicles ocellato-punctate. Surface of ossicles very rarely truncate. If truncate, the flattened surface is not striated so as to simulate the asteroid madreporite.

Material.—Only very fragmentary specimens of this species are known. The best preserved specimen is in the collection of Dr. Blackmore, of Salisbury, and is figured on Pl. XXIX. Dr. Blackmore also possesses other specimens belonging to this species. Two specimens of the species are also preserved in the British Museum (Nat. Hist.), and bear the registered numbers E. 5019 and E. 2566 respectively. The first-named specimen was presented by Mr. W. McPherson. The second specimen was originally figured by Forbes in Dixon's 'Geology of Sussex,' pl. xxi, fig. 16, as a "fragment of an *Oreaster*." In Part III of this Monograph it was figured under my direction (Pl. XXV, figs. 6, 6 *a*) as Genus (?), Sp. (?). I have now isolated two or three ossicles from the specimen, and they are figured on Pl. XXIX, fig. 9. They show that the ossicles as originally figured merely present their interior aspect. The specimen E. 5019 is taken as the type.

Description.—The state of preservation of the fragmentary specimens of this species only allows adequate description of the ossicles of the disc. These are very uniform in character, and only differ from those of *Stauranderaster ocellatus* in the absence of the truncated summit with madreporiform striations. The largest ossicle measures about 6 mm. in diameter.

The isolated ossicles figured on Pl. XXIX show the characteristic shape of marginal ossicles belonging to the genus *Stauranderaster* (see p. 120), and assist us in ascribing not only this species, but also *S. ocellatus*, to which the species is closely allied, to that genus.

Locality and Stratigraphical Position.—The specimen presented to the British Museum (Nat. Hist.) by Mr. W. McPherson, is from the *Marsupites* zone at Brighton. The specimens in the collection of Dr. Blackmore are from Micheldever, Hants (zone of *Micraster cor-anguinum*).

Order—CRYPTOZONIA, *Sladen*, 1886.

Family—LINCKIIDÆ, *Perrier*, 1875.

Cryptozonate Asteroidea, with comparatively well-developed marginal plates, always contingent. Disc small, rays long and cylindrical. Abactinal skeleton tessellate. Tegumentary developments granulate, superambulacral plates usually present. Pedicellariæ (rarely present) excavate or foraminate.

Genus—LINCKIA, *Nardo*, 1834.

LINCKIA, *Nardo*, 1834. De Asteriis, Oken's Isis, p. 717.
OPHIDIASTER (pars), *Müller and Troschel*, 1890. Monatsber k. preuss. Akad. Wiss. Berlin, p. 103.
LINCKIA, *Gray*, 1841. Ann. Mag. Nat. Hist., vol. vi, p. 284.
ACALIA (sub. gen.), *Gray*, 1841. Tom. cit., p. 285.

Arms more or less cylindrical. Dorsal plates small, not arranged regularly in longitudinal series. Two or three rows of granules on the adambulacral plates. Superambulacral plates present. Papular areas distributed irregularly between the dorsal plates.

1. LINCKIA, ? sp. Pl. XXVII, figs. 1, 1 *a*.

Material.—A distorted specimen, which very probably belongs to the genus *Linckia*, is preserved in the British Museum (Nat. Hist.) (E. 5055, Capron Coll.).

Description.—The disc is small and very much distorted. The ventral aspect of one arm is the only portion of the star-fish which affords much opportunity for description. The arm is about 18 mm. long and 4 mm. broad, and possesses the cylindrical characteristic shape of the genus. It is composed of a large number of square ossicles, which are superposed in the cross-section of the arm, so far as it can be seen. They possess no spines, but a regular granulation appears to run lineally across their breadth.

Remarks.—This specimen is not sufficiently well preserved to ascribe it to a definite species of the genus.

Stratigraphical Position.—Lower Chalk.

CRETACEOUS OPHIUROIDEA.

Order—ZYGOPHIURÆ, *Bell* (1892).

Ophiuroidea, in which the movement of the ossicles on one another is limited by the development of lateral processes and pits. Superior, inferior, and lateral spine-bearing arm-plates are always present. The arms are simple and cannot coil round straight rods.

Family—OPHIOLEPIDIDÆ.

Zygophiuræ with oral papillæ from three to six, of which the last may be infradental. Arm incisures on the disc. Dental papillæ absent.

Genus—OPHIURA, *Lamarck*, 1801.

OPHIURA, *Lamarck*. Histoire Naturelle des Animaux sans Vertebres, vol. ii.
OPHIOLEPIS, *Müller and Troschel*, 1842. System der Asteriden (Braunschweig).
OPHIOGLYPHA, *Lyman*, 1865. (Ophiuridæ and Astrophytidæ) Ill. Cat. Mus. Comp. Zool. Harvard, Nos. i, viii; 1882, Rep. Challenger Zool., vol. v.
— *Verrill*, 1899. Report on the Ophiuroidea collected by the Bahama Expedition in 1893; Iowa City, Bull. Labor. Nat. Hist., p. 4.

Disc covered with plates or scales which are for the most part swollen. Radial shields naked and swollen. Teeth. The inner mouth-papillæ long but

becoming smaller and shorter towards the distal oral region, where they are almost hidden by the scales of the mouth-tentacles. Arm-spines smooth and short, seldom longer than an arm-segment. Tentacle-scales numerous. The innermost pair of tentacle-pores narrow, surrounded by numerous tentacle-scales, and opening obliquely into the oral slits. In the back of the disc, where the arm joins it, a notch usually edged with papillæ. Two genital slits arise from the sides of the mouth-shields.

The following species are placed provisionally in this genus, to which the known characters would approximate them. The evidence, however, in every case is incomplete.

1. Ophiura serrata, *Roemer*. Pl. XXVII, figs. 3, 3 *a*, 3 *b*, 3 *c*, 3 *d*, 3 *e*.

Ophiura serrata, *Roemer, F. A.*, 1841. Die Versteinerungen norddeutsch. Kreidegeb., p. 28, pl. vi, fig. 23.
— — *Forbes*, 1843. Proc. Geol. Soc., vol. iv, p. 234, fig. 2.
— — *Reuss*, 1845–6. Die Verstein. böhm. Kreide-form., vol. ii, p. 58, pl. xx, fig. 26.
— — *Forbes*, 1850. In Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, p. 337, pl. xxiii, figs. 2, 3, 3 *a*, 3 *b*.
— — *Morris*, 1854. Cat. Brit. Foss., ed. 2, p. 84.
— — *Forbes*, 1878. In Dixon's Geology of Sussex (new edition, Jones), p. 369, pl. xxiii, figs. 2, 3, 3 *a*, 3 *b*.

Specific Characters.—Conspicuous pear-shaped radials. Remainder of dorsal surface of disc covered with scales. Upper arm-plates occupying great proportionate width of arm. Six, occasionally seven ?, spines on each side of arm-segment.

Material.—Only two fragments of arms were originally available for description by Roemer. The specimens described by Forbes were more nearly complete, one specimen showing a considerable portion of the disc and the proximal portion of four arms (figured on Pl. XXVII of this Monograph), now in the British Museum (Nat. Hist.), and bearing the registered number E. 5043 (Dixon Coll.). There are fragments of arms in several collections which can apparently be ascribed to this species.

Description.—The disc is 15 mm. in diameter. Almost the whole of the dorsal covering has disappeared in the specimen figured, thus exposing the inner surface of the mouth-plates. The jaws (oral angle plates) are clearly seen. They are long and slender and do not meet inter-radially. The grooves for the water

vascular canal and for the nerve-ring; and the depressions for the first mouth-tentacle and the entrance to the branch of the water vascular system are clearly shown. Fragments of the scaly covering of the disc are seen scattered over the disc. The peristomial plates are not recognisable, as is also the case in modern species of *Ophiura*. The arms are 3 mm. wide at the base. The upper arm-plates near the disc are broad. Six (or seven?) spines, which are in length about a third of the length of the arm-segment, are present.

The vertebral ossicles are figured on Pl. XXVII, figs. 3 *c*, 3 *d*, 3 *e*. They show the typical Ophiurid structure as displayed by modern species of Zygophiurids.

Locality and Stratigraphical Position.—Upper Chalk, Bromley, Kent.

2. Ophiura Fitchii, n. sp., *ex Forbes*, MS. Pl. XXVII, figs. 2, 2 *a*, 2 *b*.

Specific Characters.—Body large and stoutly built. Disc covered with large swollen plates. Radials contiguous, large, kidney-shaped. Upper and lower arm-plates small.

Material.—An external cast in flint, the sole remains of this species, is preserved in the Norwich Museum (No. 2294).

Description.—Very little can be made out concerning the structure of this ophiurid. The disc appears to have been surrounded with a circlet of large radials. It has a diameter of about 16 mm.

A plasticine mould of the lower portion of the cast is figured on Pl. XXVII, fig. 2 *a*. The jaws (oral angle plates) are distinctly seen. They were long and slender, and similar in form to those of *O. serrata*. Similarly a peristomial plate is not visible. The inter-radial rounded buccal shield is clearly seen. The arm is 4·5 mm. broad at the base. The impression of the cast of the arm appears to indicate that both upper and lower arm-plates were small, as the side arm-plates appear to meet in the dorsal and ventral median lines.

Locality and Stratigraphical Position.—From flint gravel, Mousehold, Norwich.

3. Ophiura parvisentum, n. sp. Pl. XXVII, figs. 4, 4 *a*.

Specific Characters.—Disc covered with small plates, radials inconspicuous. Proximal upper arm-plates only occupying about one third of dorsal surface of arm. Five spines on each side of arm-segment.

Material.—There is only one specimen of this species. This is preserved in the British Museum (Nat. Hist.), and bears the registered number E. 5052 (purchased of Simmons).

Description.—The disc is about 15 mm. in diameter. It is covered with a large number of small plates, which are rather scattered. The arms are 3 mm. broad at the base. The upper arm-plate is much narrower than in *O. serrata*. There are five spines, about three quarters the length of an arm-segment, on each side of the arm.

Locality and Stratigraphical Position.—Upper Chalk, Bromley, Kent.

Genus—OPHIOTITANOS,[1] novum.

Disc covered with plates which are small and sub-equal. Radial shields small, triangular, naked, scarcely swollen. Arm-spines small. Mouth-shields large. Side mouth-shields small, widely separated.

1. Ophiotitanos tenuis, n. sp. Pl. XXVIII, figs. 1, 1 *a*, 2, 2 *a*.

Proximal upper arm-plates longer than broad. Spines very short, five in number. Disc, with the exception of the radial plates, covered with an extensive granulation.

Material.—The material for the description of this species consists of several specimens in the British Museum (Nat. Hist.), The specimen E. 5056, which is the type, is figured on Pl. XXVIII, fig. 1, and the specimen E. 5057 on Pl. XXVIII, fig. 2. There are also specimens registered E. 5058, E. 5059, 57512. All are in a fair state of preservation. The first four specimens are from the Capron Coll., and the latter specimen was purchased from W. Griffiths. There are further examples of the species in the Sedgwick Museum, Cambridge.

Description.—The disc is flat on the dorsal surface, and its diameter in the largest specimen is 4·7 mm. Each pair of radial shields is separated by three ornamented plates.

The mouth-shields are almost oval in shape. The side mouth-shields are small, and lie widely separated on the outer edges of the mouth-shields. There

[1] Τιτανος = chalk.

is a large number of granules in the oral region, but the tips of the jaws (oral angle plates) can be seen just above the mouth-shields. There appear to be five (or six) squarish mouth-papillæ.

The first under arm-plate is small and with rounded edges. Distally the under arm-plates are at first almost square, then roughly pentagonal, and finally triangular, with the apex pointing towards the disc. The side arm-plates meet below at about the seventeenth arm-plate. The upper arm-plates are at first hexagonal, but rapidly become roughly triangular. They are tumid in appearance and have a rounded base. They rapidly become smaller, and allow the arm-plates to meet dorsally.

There are on each arm-segment five small smooth spines considerably shorter than the length of a segment.

There appear to be two tentacle-scales, but the exact number is rather difficult to determine.

Locality and Stratigraphical Position.—Lower Chalk, Folkestone and Dover.

2. Ophiotitanos lævis, n. sp. Pl. XXVIII, figs. 3, 3 *a*, 4, 4 *a*.

Specific Characters.—Spines longer than arm-segments. Upper arm-plates broader than long. Plates of dorsal surface of disc not hidden by granules.

Material.—Only one specimen is known. This is preserved in the British Museum (Nat. Hist.), no. E. 5053 (purchased of Mr. Griffiths), and shows the dorsal aspect.

Description.—The diameter of the disc is 4·8 mm., being thus about the same size as *Ophiotitanos tenuis*. The arm is, however, not so broad at the base, measuring here only 1·5 mm. across. The specific characters given above separate it sharply from this last-named species. I have not been able to determine the number of spines on each arm-segment.

Locality and Stratigraphical Position.—Lower Chalk, Dover.

Remarks.—A small specimen upon the slab, no. E. 5058 (Pl. XXVIII, figs. 4, 4 *a*), may be a young member of this species, as it possesses a strong general resemblance to the above. It is peculiar in having only four arms, probably an abnormality. As explained on p. 111, *Ophioglypha bridgerensis*, Meek, is very similar in appearance to this species.

3. Ophiotitanos magnus, n. sp. Pl. XXVIII, figs. 5, 5 *a*; Pl. XXIX, fig. 13.

Specific Characters.—Proximal upper arm-plates broader than long. Spines very short, seven spines on each arm-segment. Disc, with the exception of the radial plates, covered with an extensive granulation.

Material.—There are several specimens belonging to this species in the British Museum (Nat. Hist.) and in the Sedgwick Museum at Cambridge. The specimens in the British Museum bear the registered numbers E. 5060 (Capron Coll.), E. 5050, E. 370, and E. 371 (all from J. Starkie Gardner Coll.). The first-named specimen, which shows the ventral aspect, is figured on Pl. XXVIII as the type. A specimen from the Sedgwick Museum showing the dorsal aspect is figured on Pl. XXIX.

Description.—This species is the largest of all the known Chalk Ophiuroids, the diameter of the disc being about 37 mm., and the breadth of the arm at the base 5 mm. There appear to have been two tentacle-scales.

Remarks.—Portions of the arm of this species are very similar in form to those of *Ophiura serrata*. Unless the disc is present it is difficult to separate this species from that form.

Locality and Stratigraphical Position.—Lower Chalk.

Sub-order—NECTOPHIURÆ.

Spines situated at an angle to the arm.

Family—AMPHIURIDÆ, *Ljungman*, 1867.

Zygophiuræ with oral papillæ from one to five, of which the last is generally infradental. Arms inserted on ventral side of disc. Dental papillæ absent.

Genus—AMPHIURA, *Forbes*, 1842.

Disc small, delicate, covered with naked overlapping scales, and furnished with uncovered radial shields. Teeth. Mouth-angles small and narrow. Arms long, slender, even, and more or less flattened. Arm-spines short and regular.

1. Amphiura cretacea, n. sp. Pl. XXVIII, figs. 6, 6 *a*.

Specific Characters.—Five (or six) mouth-papillæ. Two tentacle-scales. Five arm-spines. Mouth-shields triangular in shape with a curved convex base, a fair proportion of the jaws (oral angle plates) showing on the ventral surface.

Material.—The one specimen known of this species is preserved in the British Museum (Nat. Hist.), no. E. 5059 (Capron Coll.).

Description.—The disc is 3 mm. in diameter.

There are five (or six) moderately stout blunt mouth-papillæ on either side of the mouth-angle, and a triangular papilla situated infradentally. The side mouth-shields are long and narrow, with proximal and distal sides parallel. They meet in the middle. The extremities of the jaws are very obvious above these.

The arms are long and slender, and are 2 mm. broad at base. The width of arm close to disc is 1·6 mm. The first under arm-plate is small, with slight re-entering sides and a prominent median groove. The remaining under arm-plates have a pointed proximal apex, and their sides are re-enteringly curved. The distal side is convex. The side arm-plates meet proximally on the under surface in the middle line.

The five stout tapering spines are rather longer than a joint of the arm, and are situated on a proximal ridge.

Locality and Stratigraphical Position.—Lower Chalk, Folkestone.

CRETACEOUS ASTEROIDEA AND OPHIUROIDEA FROM EXTRA-BRITISH LOCALITIES.

The following are the principal species from extra-British localities which have not been mentioned in the previous portions of the Monograph. It will be seen that where accurate information is available, these species are almost entirely identical with British species.

Asterias quinqueloba, *Goldfuss*, 1826. 'Petrefacta Germaniæ,' p. 209, pl. lxiii, figs. 5 *a*—*u*.

The illustrations given of this species are very beautiful and accurate, and enable one to identify the ossicles ascribed to it as a mixture of ossicles of

Metopaster Parkinsoni (*a—p*), *Stauranderaster ocellatus* (*q—r*), and *Pentagonaster megaloplax* (*s—u*).

Various German writers have utilised the description of Goldfuss and this specific name for the identification of isolated ossicles—*e. g.* in Roemer, 1841, 'Die Verstein. norddeutsch. Kreidegeb.,' pl. vi, fig. 20, the ossicles ascribed to *A. quinqueloba* are really ossicles of *P. megaloplax*; while in Reuss, 1845—6, 'Verstein. böhm. Kreideform.,' p. 58, pl. xliii, figs. 15—20, and in Geinitz, 1872—5, 'Palæontographica,' vol. xx, pt. 2, pl. vi, fig. 7, the ossicles ascribed to *A. quinqueloba* are really ossicles of *M. Parkinsoni*.

Since the name *quinqueloba* is prior to all the other names mentioned above, it must be used instead of one of them. The simplest course appears to be to limit it in the sense of Roemer, by fixing on the specimen represented in Goldfuss's plate lxiii, fig. 5 *t*, *u*, as type of *Asterias quinqueloba*. The result of this is to replace the name *Pentagonaster megaloplax*, Sladen (antea p. 27, Pl. IV, figs. 2—4, Pl. XIII, figs.1 *a*, 1 *b*), by *Pentagonaster quinqueloba* (Goldfuss).

Asterias jurensis, *Münster*, 1826. In Goldfuss, 'Petrefacta Germaniæ,' p. 210, pl. lxiii, figs. 6 *a—h*.

Figs. 6 *a—e* represent a fragment and isolated ossicles which closely resemble *Calliderma Smithiæ*, and figs. 6 *f—h* represent isolated ossicles bearing an equally strong resemblance to *Stauranderaster Boysii*. The species, however, is said to be "e calcareo jurassi Wurthembergia et Baruthino," whereas *C. Smithiæ* and *S. Boysii* are typical Cretaceous species, and have not in any other work been described from Jurassic rocks. Without seeing the original specimens no one should assert that Münster was so far mistaken as to the horizon and locality of the fossils before him. We can only suspend judgment.

Asterias tabulata, *Goldfuss*, 1826. 'Petrefacta Germaniæ,' p. 210, pl. lxiii. figs. 7 *a—g*.

Figs. 7 *a—b* are illustrations of isolated ossicles of *Stauranderaster argus* which are found in the Upper Chalk (zone of *Micraster. cor-anguinum*). I am unable to recognise the illustrations of the remaining ossicles as appertaining to any English Cretaceous species. The plates are said to be "e stratis argillaceis superioribus calcarei jurassi Baruthini." It is just possible that the locality and stratigraphical horizon are wrongly given in the case of *a* and *b*, and the name *Asterias tabulata* should be restricted to figs. *c—g*, one of those specimens being taken as type.

Asterias Schulzii, *Cotta*.

This is described and figured in Roemer, 1841, 'Die Verstein. Norddeutsch. Kreidegeb.,' p. 28, pl. vi, fig. 21, as follows: "Fünfeckig mit fünf kurzen Strahlen, unten vertieft und in der Mitte mit fünf Erhabenheiten; der vorstehende Rand gewölbt und zwischen je zwei Strahlenspitzen mit etwa 45 schmalen Täfelchen besetzt."

The description reads as if the specimen belonged to the genus *Stauranderaster*, but neither this nor the figure given is much aid in the exact identification of the species.

A cast of a fossil Asteroid is ascribed to the same species under the name of *Stellaster Schulzii*, by Geinitz, 'Palæontographica,' vol. xx, pt. 2, pl. v, figs. 3, 4. This cast, however, looks like a cast of a species of either *Calliderma* or *Nymphaster*.

Asterias? Dunkeri, *Roemer*, 1841. 'Die Verstein. norddeutsch. Kreidegeb.,' p. 27.

This species is described as follows: "Die Flächentäfelchen sind länger als breit, 4—6 eckig, schrägrandig fein gekörnt und nahe am obern Rande durchbohrt." Only isolated plates were known. I am unable to identify the species with other known Asteroids. The illustration given is not very clear.

According to Roemer, these isolated plates were described by Dunker and Koch, 1837, 'Norddeutsch. Oolithgeb.,' as plates of *Cidaris variabilis*.

Cœlaster Couloni, *Agassiz*, 1836. 'Mém. Soc. Sci. Nat. Neuchatel,' vol. i, p. 191.

No figure was given of this species by Agassiz. A fossil Asteroid figured by Fritel, 'Le Naturaliste,' vol. xvi, 1902, p. 79, as this species, appears to be somewhat like *Nymphaster marginatus*.

Cupulaster pauper, *Frič*, 1893. 'Arch. Landesdf. Böhmen,' ix, no. 1, p. 112.

This species is named from a specimen 3 mm. in diameter, which so obviously presents the large terminal plates which are common to all very young forms of starfish, that it is useless to speculate as to its identity.

Locality and Stratigraphical Position. — Cretaceous (Priesener Schichten), Waldek, near Bensen, Bohemia.

Goniaster marginatus, *Reuss*, 1845—6. 'Verstein. böhm. Kreideform.,' p. 58, pl. 43, figs. 21—32.

The illustrations of the isolated ossicles described as this species bear strong resemblance to those of *M. Parkinsoni*.

Goniaster mammillata, *Gabb*, described by *Clark*, 1892, in 'Bull. U.S. Geological Survey,' no. 97, p. 32.

"*Determinative Characters*.—Body pentagonal, provided with a dorsal and a ventral row of marginal plates that are narrower than high, and distinctly tumid on their outer surface. Only detached marginal plates preserved."

Remarks.—The isolated plates undoubtedly belong to a species of *Pycinaster* and bear a strong resemblance to those of *Pycinaster angustatus*.

"*Locality and Geological Position*.—Yellow Limestone of the middle marl bed of the Cretaceous from Vincentown, New Jersey."

Pentaceros dilatatus, *S. Meunier*, 1906. 'Le Naturaliste,' (2), vol. xx, p. 117.

The specimen described under this name is an external cast in flint, of which a plaster cast has been presented to the British Museum (Nat. Hist.), E. 13075. Owing to the courtesy of Professor Stanislas Meunier I have been able to examine the original specimen. It shows a well-preserved impression of the abactinal surface. The ossicles of the disc are rhomboidal or hexagonal, contiguous, of almost uniform size, about 2 mm. in diameter. The specimen, therefore, cannot be placed in the genus *Pentaceros*, and its appearance, measurements, and type of ornament enable me to ascribe it to *Pentagonaster obtusus*.

Ophioglypha bridgerensis, *Meek*, described and figured by *Clark*, 1892. 'Bull. U.S. Geological Survey,' no. 97, p. 29.

'*Determinative Characters*.—Disc composed of numerous small imbricating plates. Upper arm-plates wider than long, the outer angles sharp and expanding between the side arm-plates, which are slightly smaller. Under arm-plates long and nearly rectangular in shape.

"*Dimensions.*—Diameter of disc 6 mm. Length of arm 20 mm. Width of arm near disc 1·25 mm."

Remarks.—The figures given and dimensions of this species appear to me to indicate that it closely resembles *Ophiotitanos lævis*. The upper arm-plates are described as hexagonal, and the more proximal upper arm-plates of the British species present this appearance.

Locality and Stratigraphical Position.—Cretaceous, Fort Ellis, Montana.

Ophioglypha texana, *Clark*, 1892. 'Bull. U.S. Geol. Survey,' no. 97, p. 30.

"*Determinative Characters.*—Disc round; composition indistinct. Arms long, with wedge-shaped under arm-plates about as wide as long; upper arm-plates about twice as wide as long.

"*Dimensions.*—Diameter of disc 15 mm. Length of arm 50 mm. Width of arm at disc 2 mm."

Remarks.—It is difficult to identify this with a British species, but the illustrations appear to indicate that it is somewhat similar to *Amphiura cretacea*.

Locality and Stratigraphical Position.—Cretaceous, six miles north of Fort Worth.

Ophiura granulosa, *Roemer*, 1841. 'Die Verstein. norddeutsch. Kreidegeb.,' p. 28, pl. vi, fig. 22.

This species is described as follows:

"Die Arme sind walsenförmig und bestehen aus gewölbten, seitlich durch ein Furche getrennten, deutlich gekörnten Seitenschildchen; wo sich deren vier berühren liegt ein kleines, dreieckiges Schildchen dazwischen."

Remarks.—The small fragment of the arm figured shows it to be a portion of the distal extremity—quite possibly the distal extremity of some species of *Ophiotitanos*.

Locality and Stratigraphical Position.—Lower Chalk, Lindener Berg, near Hanover.

Ophiura ? pulcherrima, *Frič*, 1893. 'Arch. Landesdf. Böhmen,' vol. ix, no. 1, p. 113.

Remarks.—No description is given. The figure does not show any resemblance of this species to other known forms, but the specimen was obviously imperfect. The upper arm-plates appear to be V-shaped.

Locality and Stratigraphical Position.—Cretaceous (Priesener Schichten), Waldek, near Bensen, Bohemia.

Stellaster albensis, *Geinitz*, 1872—5. 'Palæontographica,' vol. xx, pt. 2, p. 16, pl. vi, fig. 3.

Remarks.—This species is only known from a cast from the Quadersandstein. In the absence of determinative characters it is impossible to say whether it is identical with or differs from more fully described species.

Stellaster Coombii, *Forbes*, sp., in *Geinitz*, 1872—5, 'Palæontographica,' vol. xx, pt. 2, p. 17, pl. vi, figs. 4—6.

The specimens illustrated here as *S. Coombii* certainly do not belong to Forbes' species of that name. They appear to be ossicles of various species, but I am unable to identify them from the figures given.

SPECIFIC AND GENERIC CHARACTERS IN CHALK ASTEROIDEA.

When I commenced this account of Cretaceous Asteroids I endeavoured, so far as possible, to follow the generic classification of previous authors and especially to preserve the continuity of Mr. Sladen's work. More recent work, however, has led me to believe that the shape of the marginal plates, together with their ornament, affords the best determinative generic and specific characters, and further enables us to identify almost all Cretaceous starfishes from single isolated plates.

Some necessary revision as to nomenclature in both genera and species is given below, together with an illustrated key-table, which it is hoped will enable zonal collectors to identify the isolated asteroid plates which are commonly met with in

almost all exposures. Up to the present our knowledge of the zonal occurrence of these forms has been limited, as complete specimens of starfishes are exceedingly rare. There appears to be no reason now, however, why our knowledge of the zonal distribution of these forms should not become as nearly complete as it is, for example, in the case of Echinoids.

I must thank Dr. Blackmore, of Salisbury, for his invaluable suggestions to me concerning this means of identification.

Ornament.—The ornament of starfishes consists of calcareous pieces, which may be spinous in form, or scaly, or granular. These may occur:

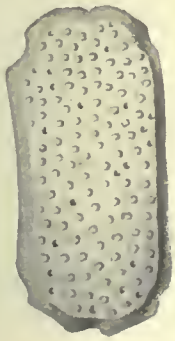
(1) Embedded in the living tissues outside the general body-plates, but not in contact with the plates themselves. On the death of the animal they become dispersed on the disintegration of the living tissues, and such ornament is therefore rarely visible in fossil specimens.

(2) Articulated to the plates. In this case they are situated:

(a) Either in a depression of the plate;

(b) Or in a depression upon a raised eminence of the plate. Occasionally in this latter case the depression may be excavate in the centre in order to allow a strong muscular attachment. In this case the eminence may simulate the perforate tubercle of an Echinoid such as *Cidaris*.

Text-fig. 3.—Isolated marginal of *Nymphaster Coombii*, showing spines and spine-pits.



Text-fig. 4.—Isolated marginal of *Stauranderaster bulbiferus*, showing the "pustulate" type of ornament.

In almost all cases in Cretaceous Asteroids the ornament is of the type 2 a.

Generally the movable articulated pieces have disappeared, but in such cases the depression on the plate which they formerly occupied is readily visible (compare Text-fig. 3).

I purpose to call all such movable articulated pieces, whether they are spinous or granular in character, "spines," and, at the suggestion of Dr. Bather, the depressions on the plate "spine-pits."

The character of the spine-pits appears to be constant in character in each individual species. Thus, *e.g.* in *N. Coombii* (Text-fig. 3) they show a coarse honeycomb structure, uniform in character over the whole of the plate. In *Stauranderaster bulbiferus* (Text-fig. 4) the spine-pits are circular and widely spaced. This latter type is interesting, as it apparently occurs only in the genera *Metopaster* and *Stauranderaster*. The spine is very small, and barely projects over the edge of the deep

spine-pit, thus giving the plates an embossed appearance. This type of ornament I call the "pustulate" type.

In previous portions of this Monograph both Mr. Sladen and myself have assumed that if no spine-pits are present on a plate they have been weathered away. It now appears that the absence of spine-pits is such a constant character in certain species that this supposition can no longer be held, and the absence of spine-pits indicates an original absence of spines, or, at any rate, spines articulated to the plates. In support of such a conclusion it can be urged that, generally speaking, Chalk fossils are but little weathered, and that there is evidence derived from a study of recent forms.

Text-fig. 5.—Pedicellaria of *Nymphaster oligoplax*.

Text-fig. 6.—Three pedicellaria from *Pentagonaster quinqueloba* on the right. A pedicellaria from *Hadrandcraster abbreviatus* on the left.

Text-fig. 7.—A pedicellaria from *Metopaster Parkinsoni* in the centre, on the left a pedicellaria of *Pycinaster senonensis*, on the right a pedicellaria of *Stauranderaster coronatus*.

Pedicellariæ.—As can readily be understood, only pedicellariæ which are articulated in depressions of the plate are preserved in Cretaceous Asteroids. Purse-like, valvate pedicellariæ (Text-fig. 5) of a generalised type are common to many genera. More specialised pedicellariæ, however, peculiar to the genera *Metopaster* and *Pycinaster* are also met with (Text-fig. 7).

KEY-TABLE FOR THE IDENTIFICATION OF CRETACEOUS ASTEROIDS.

The following key-table is based on the shape of the marginal plates and the character of the spine-pits on them. Generally speaking both superior and inferior series are similar in these respects, but when otherwise a note is made in the table.

A short description is also given of various plates which cannot be adequately treated in the table.

All the plates figured in the table are magnified 4 diameters.

It is convenient to consider the Chalk (Cenomanian-Senonian) species separately from the Upper Greensand forms. No Cretaceous Asteroidea have been described from below this horizon.

CHALK (CENOMANIAN-SENONIAN) SPECIES.

I.—**Marginals four-sided, with sides rectilinear or almost rectilinear; broad.**

A. Without a rabbet-edge. *Calliderma*, *Nymphaster*, *Pentagonaster*.
B. With a rabbet-edge. *Metopaster*, *Mitraster*.
C. With a distinct ridge. *Arthraster*.

II.—**Marginals either hexagonal or rounded; very thick.** *Hadranderaster*.

III.—**Marginals wedge-shaped, high, spine-pits very shallow or absent.** *Pycinaster*.

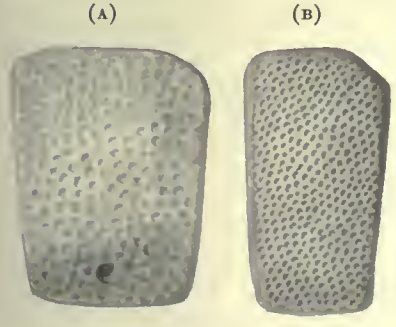
IV.—**Marginals breast-plate-shaped.** *Stauranderaster*.

V.—*Miscellaneous plates*.

I.—**Marginals four-sided, with sides rectilinear or almost rectilinear. Pedicellariæ when present of a simple bi-valvate character.**

A. Without a rabbet-edge. *Calliderma*, *Nymphaster*, *Pentagonaster*.

1. Spine-pits shallow, hexagonal, giving a honeycomb appearance.



TEXT-FIG. 8.

a. Honeycomb medium or fine. *C. Smithiæ* (see p. 123).
Text-fig. 8 A.—Variety with medium-sized spine-pits (see p. 123).
Text-fig. 8 B.—Variety with fine spine-pits (see p. 123).

b. Honeycomb coarse. *N. Coombii*. Text-fig. 3, p. 113.

TEXT-FIG. 9.

c. Honeycomb confined to a portion of the plate (or absent). *P. obtusus*. Text-fig. 9.

2. Spine-pits shallow, circular, circles variable in size, adjoining.

TEXT-FIG. 10.

One species, *C. latum*. Text-fig. 10.

3. Spine-pits deep, circular, not adjoining.

TEXT-FIG. 11.

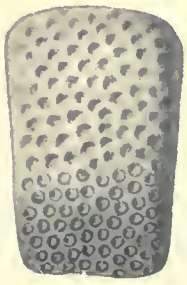
TEXT-FIG. 12.

a. Spine-pits coarse. *N. marginatus*. Text-fig. 11.
b. Spine-pits fine, not on margin. *N. oligoplax*. Text-fig. 12.

TEXT-FIG. 13.

c. Spine-pits fine, uniformly over the whole of plate. *P. lunatus*. Text-fig. 13.

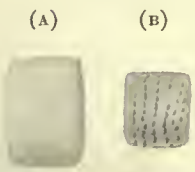
4. Spine-pits on outer edge of plate with raised margins.



TEXT-FIG. 14.

One species, *P. quinqueloba* (see p. 108). Text-fig. 14.

5. No spine-pits present.



TEXT-FIG. 15.

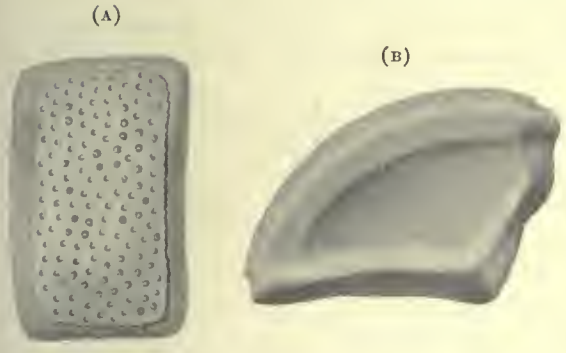
a. Proximal marginalia almost smooth; distal with granular rugosities arranged in a linear series. *N. radiatus*. Text-fig. 15, (A) proximal marginal, (B) distal marginal.

TEXT-FIG. 16.

b. Marginalia with rugosities not arranged in linear series. *N. rugosus*. Text-fig. 16.

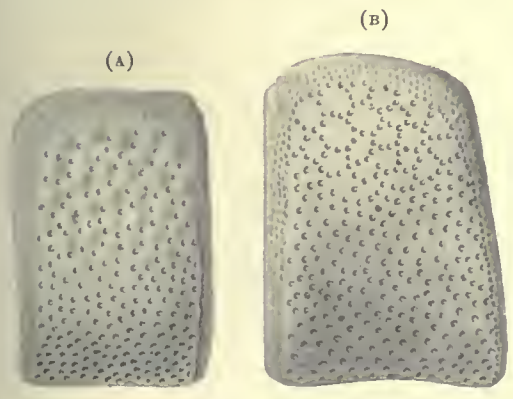
B. Marginals with a rabbet-edge. Rabbet-edge covered with small spine-pits. Pedicellariæ when present "winged" (see Text-fig. 7).

1. Spine-pits on central raised area.



TEXT-FIG. 17.

a. Central raised area smooth on both superior and inferior marginalia. Spine-pits on infero-marginalia uniformly situated. *M. Parkinsoni*. Text-fig. 17, (A) outer view of marginal, (B) side view of marginal.

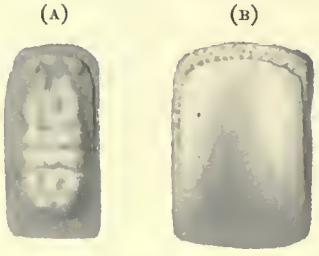


TEXT-FIG. 18.

b. Central raised area of supero-marginalia rugose; that of infero-marginalia smooth, with spine-pits in form of network. *M. Hunteri*. Text-fig. 18, (A) supero-marginal, (B) infero-marginal.

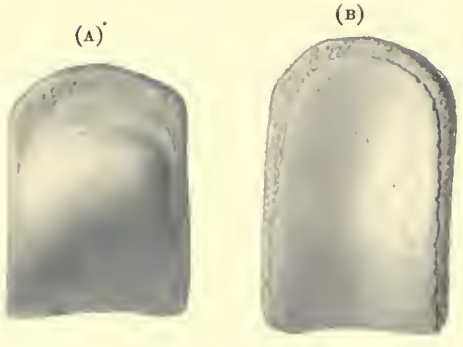
c. Central raised area of supero-marginalia smooth in young, rugose in mature individuals. Lower Chalk form. *M. cornutus* (see p. 124).

2. No spine-pits on central raised area.



TEXT-FIG. 19.

a. Rugosities present on greater portion of surface of supero-marginalia. *M. rugatus.* Text-fig. 19, (A) supero-marginal, (B) infero-marginal.



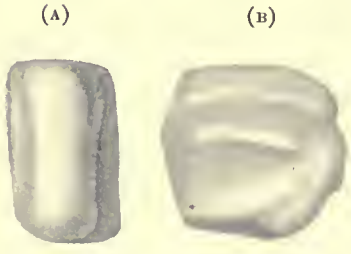
TEXT-FIG. 20.

b. Rugosities confined to inner edge of supero-marginalia or absent; outer portion of plate tumid. *α*. Plates oblong. *M. uncatus.* Text-fig. 20, (A) supero-marginal, (B) infero-marginal. *β*. Plates square. *M. quadratus.*

c. No rugosities present on the supero-marginalia which are not tumid on their outer portion. *M. compactus.* See Pl. XXVI, fig. 3 *b*.

N.B.—The infero-marginalia of the above species are difficult to distinguish except by their dimensions. The reader is advised to refer to the detailed description for these.

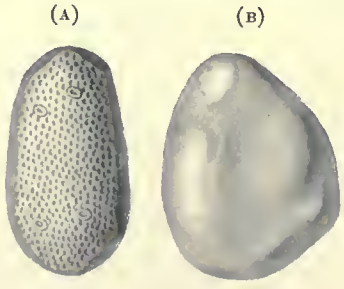
c. Marginalia with a distinct ridge which has granular elevations along its base. *Arthraster.*



TEXT-FIG. 21.

1. Upper surface of ridge smooth. *A. Dixoni.* Text-fig. 21, (A) outer view of marginal, (B) side view of marginal.
2. Upper surface of ridge with spine-pits. *A. cristatus.* See Pl. XXIX, fig. 10.

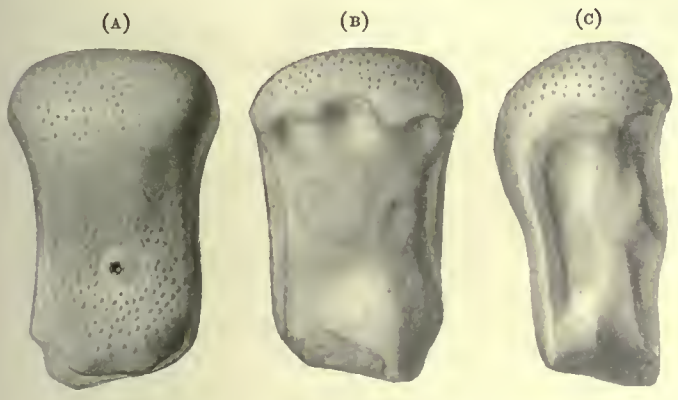
II.—**Plates either hexagonal or rounded ; very thick. Spine-pits form a distinct, fine honeycomb marking.** *Hadranderaster* (see p. 125).



TEXT-FIG. 22.

There is only one species. *H. abbreviatus.* Text-fig. 22, (A) outer view of marginal, (B) side view of marginal.

III.—**Marginals generally wedge-shaped, high, spine-pits very shallow or absent. Pedicellariæ when present with five valves round a deep central depression.** *Pycinaster.*



TEXT-FIG. 23.

1. Plates of maximum height, 10 mm. *P. angustatus.* See Pl. IX, fig. 1 *a*.
2. Plates of maximum height, 20 mm., ∩-shaped in profile. *P. senonensis.* Text-fig. 23, (A) outer view of marginal, (B) interior view of marginal, (C) side view.

TEXT-FIG. 24.

3. Plates very thick, often oblong, not wedge-shaped. *P. crassus.* Pl. XXIX, fig. 3, exterior view of marginal. Text-fig. 24, side view of marginal.

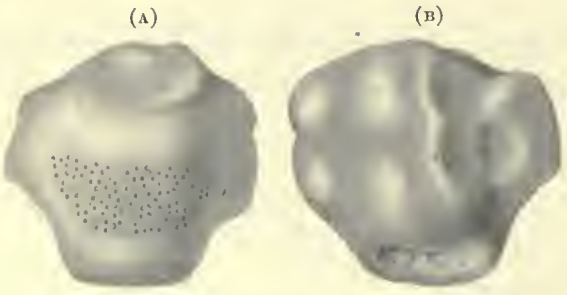
IV.—**Marginal plates breast-plate-shaped.** *Stauranderaster* (see p. 125).

A. With spine-pits.

TEXT-FIG. 25.

TEXT-FIG. 26.

1. Spine-pits fairly coarse. *S. bulbiferus* (commonly occurring). Text-fig. 25.
2. Spine-pits medium. *S. bipunctatus* (only one specimen known). Text-fig. 26.



TEXT-FIG. 27.

3. Spine-pits fine. *S. Boysi.* Text-fig. 27, (A) outer view of marginal, (B) interior view of marginal.

B. Without spine-pits.

TEXT-FIG. 28.

TEXT-FIG. 29.

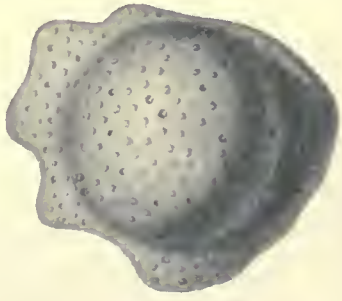
1. Maximum size about 7 mm. *S. coronatus.* Text-fig. 28.
2. Maximum size about 2·5 mm. *S. squamatus.*
3. Maximum size about 2·5 mm. *S. pistilliferus.* Text-fig. 29.

N.B.—It is impossible to distinguish isolated marginalia of these two species. Compare V, 3 (p. 121).

V.—*The collector may also come into possession of the following plates:*

1. Large triangular plates having the characteristic ornament of *Metopaster.* These are the ultimate supero-marginalia which characterise the genus. See *e. g.* Pl. XVI, fig. 2 *a*.

2. Large hemispherical plates with a flattened base. These are met with in the following species:



TEXT-FIG. 30.

A. With spine-pits.

Stauranderaster bulbiferus, S. Boysi, and ? *S. bipunctatus.* These are distinguished from one another by their spine-pits, which are of the same character as those met with in the marginalia. Text-fig. 30= a primary inter-radial of *S. bulbiferus.*

B. Without spine-pits.

Pycinaster senonensis, distinguished by the smooth surface, Pl. XXIX, fig. 6.

Arthraster Dixoni, distinguished by the rugose surface, Pl. XXIX, fig. 11.

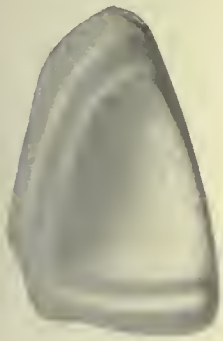
3. Nodular plates with an excavate margin met with in the following species:

A. With flattened base, from 7—9 mm. in diameter, *S. coronatus*, Pl. XXIV, fig. 2.

„ „ „ 3—4 mm. „ *S. squamatus*, Pl. XXV, fig. 3.

B. With produced base, *S. pistilliferus*, Pl. XXV, fig. 5.

4. Oblong or almost oblong plates having the characteristic ornament of *S. bulbiferus*. These are the more distal marginals, or in some cases the ventro-lateralia of this species. Generally the marginals are indented at the corners, and their shape can be decided from the characteristic breast-plate form.



TEXT-FIG. 31.

Text-fig. 4, p. 113.—Outer view of plate.
Text-fig. 31.—Side view of plate.

5. Irregularly rounded or polygonal plates with ocellate depressions having a raised ridge.

TEXT-FIG. 32.

A. Without madreporiform markings on summit. *S. argus*. Pl. XXIX, fig. 8 *a*.

B. With madreporiform markings on summit. *S. ocellatus*. Text-fig. 32.

6. One specimen of *Astropecten*? sp. and *Linckia* sp.? respectively have also been described, see pp. 90 and 100.

UPPER GREENSAND FORMS.

The genus *Comptonia* appears to be characteristic of this horizon. The plates are very similar in shape to those of *Calliderma*, except that they are more rounded in profile. Unfortunately, no specimen at present known shows the ornament of the marginalia.

I have also met with *C. Smithiæ* and *P. punctatus* from this horizon. They are readily distinguished by the characters which have already been given in the key-table.

NOTES ON THE KEY-TABLE.

Genera—Calliderma, Nymphaster, Pentagonaster.

The following are the chief distinctive characters which separate these three genera in recent forms.

Calliderma.	Pentagonaster.	Nymphaster.
1. Arms well produced.	Arms slightly produced.	As in *Calliderma*.
2. Abactinal area covered with closely fitting plates.	As in *Calliderma*.	Abactinal area covered with paxillæ, which are not closely fitting in the radial areas.
3. Ventro-lateral and infero-marginal plates with prominent spines.	Ventro-lateral and infero-marginal plates without prominent spines.	As in *Pentagonaster*.
4. Armature of the adambulacral plates consisting of 14–16 small spines arranged uniserially, with three or four rows of larger spines arranged rather irregularly.	Armature of the adambulacral plates arranged in longitudinal series. Series on the whole uniform in character.	As in *Pentagonaster*.

The fossil species of *Calliderma* possess the characters numbered 1 and 2, but differ to a greater or less extent in characters 3 and 4, in which they resemble *Pentagonaster*. The genus *Calliderma* was, however, founded by Gray on one species—*C. emma*. No other recent species has been assigned to the genus. It is difficult, therefore, to say how far the distinctive characters of the Cretaceous genera should have generic value. The question is debated by Mr. Sladen on p. 5 of this Monograph, and the very striking general resemblance of the fossil species to the recent *C. emma* influenced him in his decision to group them under this genus. There appears no great reason to dispute this assignment, but I am in more doubt as to the systematic position of the species which have been placed in the genera *Pentagonaster* and *Nymphaster*. It will be seen that as the fossil species of *Calliderma* resemble *Pentagonaster* in characters 3 and 4, the only distinctive character which remains between the two genera is the length of the

arm. Two of the fossil species of *Pentagonaster*, namely *P. lunatus* and *obtusus*, have all arms which are well produced (the arms in the specimen of *P. lunatus* figured on Pl. IV, fig. 1, are broken off short). The third and remaining species, *P. quinqueloba*, is usually much more pentagonal in shape, although a specimen in the possession of Dr. Blackmore has a major radius at least twice the magnitude of that of the minor radius.

The species assigned to the genus *Nymphaster* by Sladen were so assigned because their structure and character, so far as they could be made out from the fragmentary condition of the fossils, appeared to warrant their inclusion in the genus *Nymphaster* (see p. 15).

It appears to me that these species have the same generalised characters as those assigned to the genera *Calliderma* and *Pentagonaster*. The distinctive character of the genus *Nymphaster* is the possession of paxillæ on the abactinal plates. No fossil species is sufficiently well preserved to show whether these were absent or present, and it is impossible therefore to confirm or deny Sladen's suggestion.

It will be seen from the above that there is no certain evidence which entitles us to distribute the Cretaceous species amongst the three genera, and it may be the task of a future observer to place them in one new genus. I have, however, in order to secure uniformity, utilised all these generic names even for the description of new species. The following species also appear to require revision.

Calliderma Smithiæ, *C. mosaicum*.

After examination of the fairly numerous specimens of the fossils assigned to these species in the British Museum (Nat. Hist.) I cannot confirm the specific distinctions made by Sladen on pp. 10 and 11 of this Monograph. All the characters mentioned vary greatly in individual specimens. The ornament, however, is common in character to both species, and I should prefer to unite them in one species, namely, *C. Smithiæ*, as this has prior place in the original account given by Forbes.

The specimens figured on Pl. VII, figs. 1 and 2, and stated by Sladen to be in his opinion doubtful examples of *N. Coombii* (p. 17), should in my opinion be assigned to *C. Smithiæ*, as should also the specimen figured on Pl. XIX, fig. 3. These examples possess a finer type of honeycomb structures on their marginalia than is usually met with in *C. Smithiæ*, and they may, therefore, be a distinct variety of this species (see Text-fig. 8).

A specimen preserved in the British Museum (Nat. Hist.) E. 5063, was figured by Sladen on Pl. V, fig. 1 *a*, of this Monograph as *Tomidaster sulcatus*. Apparently it was the intention of Sladen to make a new genus and species for the reception

of this fossil. The dimensions of the marginalia, compared with the minor radius and the ornament, are precisely the same as in *C. Smithiæ*, from which the specimen only differs in the possession of numerous valvate pedicellariæ. In view of the somewhat freakish way in which pedicellariæ occur in starfishes, it does not appear to me that this character alone entitles us to make a specific or generic distinction on behalf of this specimen.

There is another specimen also in the collection of the British Museum (E. 1116) which has similarly numerous valvate pedicellariæ, but which shows the abactinal aspect. In all other respects the specimen cannot be distinguished from a specimen of *C. Smithiæ*.

Genus—Metopaster.

In the key-table I have only distinguished four species of *Metopaster*, namely, *M. Parkinsoni*, *M. uncatus*, *M. quadratus*, and *M. cornutus*, the latter being a doubtful species. If one examines collections of Cretaceous Asteroids, one finds that practically all the specimens have been rightly assigned to these species. Specimens which could be assigned to the species *M. Mantelli*, *M. Bowerbanki*, *M. zonatus*, *M. sublunatus*, *M. cingulatus* (see pp. 38–55), are very rarely met with.

The very considerable variation which occurs in undoubted specimens of *M. Parkinsoni* in the number of the supero-marginalia, their form, amount of ornament, and the shape of the ultimate plates of this series, makes specific characters founded solely upon these characters of doubtful validity, particularly as such variations occur even in an individual specimen, and it is upon a rather extreme variation of these characters occurring in very few specimens that this large number of species have been described. On the other hand, the presence or absence of spine-pits on the raised central area of the plate is a constant character in species of *Metopaster*. Two specimens figured in the Monograph appear to belie this statement. The specimen figured on Pl. X, fig. 4 *a*, shows no spine-pits on its infero-marginalia, but is figured as *M. Parkinsoni*. I have isolated a dorsal ossicle, which shows the specimen undoubtedly to belong to *M. uncatus*. The specimen figured on Pl. XI, fig. 3 *a*, as *M. uncatus*, shows spine-pits on its supero-marginalia in one inter-radius only. After very careful examination of this specimen, I have come to the conclusion that this inter-radius —the right-hand upper inter-radius of the figure—has been added by a dealer from a collection of ossicles of *M. Parkinsoni* to an imperfect specimen of *M. uncatus*.

Text-fig. 33.—Marginal of *Metopaster Parkinsoni*, showing a more scattered type of ornament than that usually met with.

Genus—STAURANDERASTER,[1] novum.

PENTACEROS (pars). Pp. 76–89 of this Monograph.

The species *bulbiferus*, *Boysii*, *coronatus*, *ocellatus*, *bispinosus*, *pistilliferus*, and *squamatus* (pp. 76—89 of this Monograph), which have been formerly placed in the genus *Pentaceros*, together with the new species *argus* (p. 99), should, I think, now be ascribed to a new genus. The plates of these species are breast-plate-shaped, at times almost cross-shaped, and bear a characteristic type of ornament (see p. 113). In both these respects and in the absence of papular areas the species differ widely from species of recent *Pentaceros*, with which the only feature they have in common is the circlet of raised plates on the abactinal surface of the disc.

The type species of the new genus is *Stauranderaster Boysii*, and its diagnostic characters are :

Arms high, well produced, marginalia breast-plate-shaped, generally with a rabbet-edge free from ornament, and a raised interior area, either smooth or with ornament of an embossed type. A circlet of swollen plates present on the abactinal surface of the disc.

This genus, with the following genus, may be placed provisionally in the family Pentacerotidæ.

Genus—HADRANDERASTER,[2] novum.

PENTACEROS (pars), p. 86 of this Monograph.

The species described as *Pentaceros abbreviatus* on p. 86 of this Monograph differs so considerably in the shape of its marginalia and their ornament from the species of *Stauranderaster* and recent species of *Pentaceros* that I have placed it in a new genus.

The type species is *Hadranderaster abbreviatus*, and the diagnostic characters of the new genus are :

Arms high, well produced, marginalia either hexagonal or rounded, very thick, ornament spread uniformly over the surface of the plate. Pedicellaria bi-valvate.

[1] σταυρός = a cross, ἄνδηρον = a raised garden border.

[2] ἁδρός = stout, ἄνδηρον = a raised garden border.

GENERAL CHARACTERISTICS OF CRETACEOUS ASTEROIDEA AND OPHIUROIDEA.

The majority of Cretaceous starfishes belong to the Phanerozonate forms included in the families Pentagonasteridæ and Pentacerotidæ. Modern forms of the genera of these families are widely distributed geographically, but, generally speaking, they are characteristic of warmer waters than those of the English Channel of to-day.

The Chalk starfishes are specialised types which, although approximating to, are not identical with, modern genera. The differences, at any rate in some cases, appear to be distinctly physiologically advantageous.

Metopaster and Mitraster, the most abundant of all Chalk starfishes, possess not only a specialised type of ornament but also characteristic massive plates. The arms tend to become shortened and the disc correspondingly enlarged.

The Chalk species of the Pentacerotidæ differ from the modern forms, inasmuch as they are more strongly built; the abactinal areas are not reticulate, and all species possess intermarginalia which cause the characteristically deep body of these forms.

The Chalk is a deposit formed in seas which were sufficiently distant from land to avoid any great admixture of clay or sand. *Globigerina* and other forms of pelagic Foraminifera floated in abundance on the surface of the sea, which, because of its temperature, must have been exceedingly favourable to prolific forms. In the circumstances there must have been an abundance of food for starfishes, and we find, therefore, that the long-armed, comparatively active Astropectinidæ, which were so characteristic of the Jurassic shallow water deposits, are displaced by more sedentary forms which tend to specialise, so as to obtain, by the enlargement of the disc or development of intermarginalia, the largest possible space for their digestive organs.

The irregular Echinoids which are so characteristic of the Cretaceous seas are similarly sedentary forms.

The fossil Ophiuroidea also closely resemble modern forms. The isolated vertebral ossicles of *O. serrata*, figured Pl. XXVII, figs. 3 *c*, 3 *d*, 3 *e*, cannot be distinguished from the ossicles of recent Ophiuroids. Complete specimens of Ophiuroidea and Asteroidea are rare, but isolated plates are very numerous in the Upper Chalk. They are, on the contrary, rare in the Lower Chalk, according to experienced collectors, as, for example, Mr. Dibley.

The following starfishes are found in the zones indicated. The list is compiled

from the papers of Dr. Rowe ('Proc. Geol. Assoc.,' vols. xvi, xvii), and also from notes furnished by Dr. H. P. Blackmore and Mr. T. H. Withers.

	Zone of *Ostrea-lunata.*	Zone of *Belemnitella mucronata.*	Zone of *Actinocamax quadratus.*	Zone of *Marsupites.*	Zone of *Micraster cor-anguinum.*	Zone of *M. cortes-tudinarium.*	Zone of *Holaster planus.*	Zone of *Tere-bratula gracilis.*	Zone of *Rhynchonella Cuvieri.*	Zone of *Holaster subglobosus.*	Zone of *Ammo-nites varians.*
Nymphaster Coombei, Forbes	...	...	...	...	...	...	...	...	×	...	...
— *oligoplax*, Sladen	...	...	...	...	×	...	...	...	...	...	...
Pentagonaster quinqueloba, Goldfuss	...	×	×	×	×	...	...	...	...	...	...
— *obtusus*, Forbes	...	...	×	×	...	...	...	...	...	...	...
Metopaster Parkinsoni, Forbes	...	...	×	...	×	×	×	×	...	...	...
— *uncatus*, Forbes	...	...	...	×	×	×	...	...	...	...	...
— *quadratus*, n. sp.	...	...	×	...	...	...	...	...	...	...	...
— *cornutus*, Sladen	...	...	...	...	...	...	...	...	×	...	...
Mitraster Hunteri, Forbes	...	×	...	...	×	...	...	...	...	...	...
— *rugatus*, Forbes	...	×	×	...	×	...	...	...	...	...	...
Pycinaster angustatus, Forbes	...	×	×	×	×	...	...	...	...	...	...
— *senonensis*, Valette	...	...	×	...	...	...	...	...	...	...	...
Stauranderaster bulbiferus, Forbes	...	×	×	×	×	×	...	...	...	...	...
— *Boysi*, Forbes	...	...	×	...	...	...	...	...	...	...	...
— *ocellatus*, Forbes	...	×	×	×	×	...	...	...	...	...	...
— *pistilliferus*, Forbes	...	×	×	...	...	...	×	...	...	...	...
— *argus*, n. sp.	...	...	...	...	×	...	...	...	...	...	...
Arthraster Dixoni, Forbes	...	...	...	×	...	...	...	×	...	...	...
,, *cristatus*, n. sp.	...	...	...	...	×	...	...	...	...	...	...

THE PHYLOGENY OF THE CRETACEOUS ASTEROIDEA.

If we examine the various species of a genus or group of related genera of Cretaceous Asteroids, we find that there is a similar transition from smooth to spinous forms through an intermediate form, to that which has been observed in Ammonites and Brachiopods.

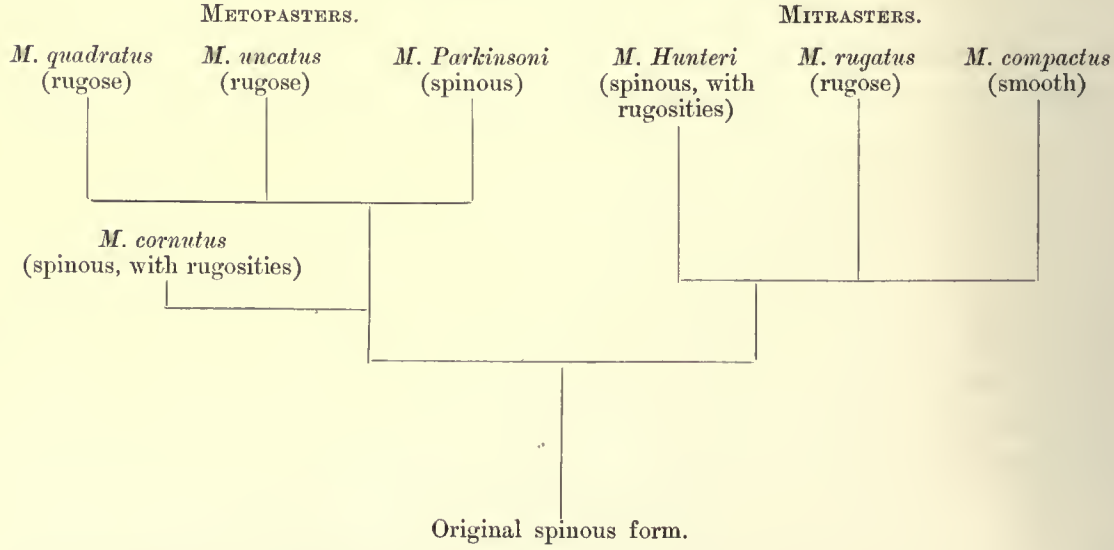
Both in Ammonites and Brachiopods single specimens show the whole life-history of the individual, for the shell of the animal is not materially altered in character after it has once been formed. It is therefore possible to show, *e. g.*, that the character of the ornament of the shell of an Ammonite was smooth in its infancy, costate in its adolescence, spinous in the adult, and it has also been shown that this life-history depicted by the individual is an epitome of the phylogenetic history of the species (Buckman, 'Mon. Ammon. Inf. Oolite,' Pal. Soc., 1905, p. cc). Similar observations have been made with regard to Brachiopods (Buckman, 'Quart. Journ. Geol. Soc.,' vol. lxiii, 1907, p. 338); primitively the Brachiopod shell is smooth externally, more advanced forms are progressively costate and then spinous. Occasionally species may regress towards a primitive

plain form through a costate phase. The progression or elaboration is known as "anagenetic" development, and the retrogression as "catagenetic."

It is regrettable that our present state of knowledge of Chalk Asteroids does not allow us to recognise such definite phylogenetic series as those obtainable in Brachiopods or Ammonites. The plates of an Asteroid are constantly being eaten away and replaced by new calcareous matter, so that the adult plate may differ considerably in character from its young phase. An opportunity for study, however, is afforded by the fact that all the plates are not formed at once. The more distal plates are younger than the proximal plates, and therefore resemble more closely those of the young form. The resemblance is not, however, quite exact, as they are formed later in the life of the individual, and may show consequently characters which have appeared later in the history of the species. Doubtless, if it were not for the paucity of the well-preserved specimens of Cretaceous Asteroids much might be still made out by a comparative study along these lines.

The following paragraphs are only suggestions made in the hope that more material may come to light at a future date. The great majority of starfishes are and have been spinous forms, and I propose to assume that the original ancestor in each group was spinous.

Genera—METOPASTER AND MITRASTER.



It is convenient in this group to consider the ornament on the raised central area of the marginalia. It will be seen from the above diagram that the spinous

form, which was the ancestor of these two groups, early gave rise to two offshoots, one of which includes the *Metopaster* species, the other the *Mitraster* species. Both genera retained evidence of common ancestry by the possession of similar ornament of the specialised "pustulate" type, and by the similar appearance of their ultimate supero-marginalia, which, instead of being smaller than the rest of the superior marginal series, are as large or larger than these. *M. cornutus*, which is the only species found in the lower zones of the chalk (Turonian), shows that early specialisation set in. This form is spinous without rugosities when young (see p. 55, Pl. XIV, fig. 5), but older specimens (see Pl. XXIX, fig. 12) acquire rugosities.

The species of *Metopaster*, *M. quadratus* and *M. uncatus*, have lost all spines from the raised central area of their supero-marginalia, and, instead, possess rugosities. The raised central areas of the infero-marginalia possess neither spines nor rugosities, but are quite smooth. *M. quadratus* has also acquired, as a frequent variation, a primitive type of ultimate supero-marginalia (see p. 98). The type of ornament shows the species to be highly specialised, and this fact, together with its occurrence in the higher zones of the Chalk, affords us an explanation of the remarkable peculiarity of the terminal supero-marginalia on the supposition that it is a catagenetic tendency.

The species of *Mitraster* show even more decided evidence of the three phases —spinous, rugose, smooth. These alterations only occur on the raised central area of the supero-marginalia. The infero-marginalia appear to pass directly from the spinous to the smooth stage without the intervention of a rugose stage.

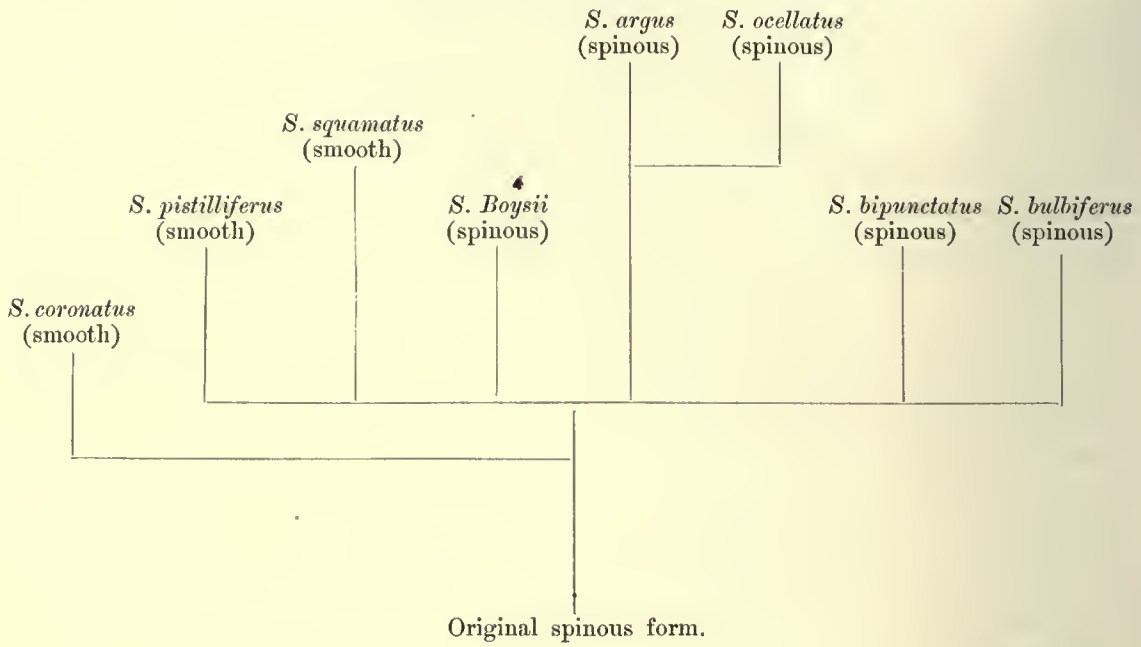
Genera—Calliderma, Nymphaster, and Pentagonaster.

This group tends to become smooth both in the Senonian and in the Turonian-Cenomanian.

Turonian-Cenomanian forms include *C. Smithiæ*, *C. latum*, *N. Coombii*, *N. oligoplax*, and *N. marginatus*, which are spinous; *N. rugosus*, which is rugose; *N. radiatus*, which is smooth on the older proximal plates, but rugose on the younger distal plates.

Senonian forms include *P. quinqueloba* and *P. lunatus*, which are spinous; *P. obtusus*, which very often possesses marginalia which have lost the majority of the spines and are almost smooth.

Genus—STAURANDERASTER.



The left-hand stem and branches of the diagram above are occupied by the generalised species which have long tapering arms. They show the transition from spinous to smooth forms. The spinous form of these species is *S. Boysii.* In the lower zones of the Chalk one species (*S. coronatus*) appears. This has neither spines nor rugosities on the majority of its marginalia, although a few distal marginalia are rugose. *S. squamatus*, which is almost identical in character with *S. coronatus*, except that it is of smaller size, and *S. pistilliferus* (arms not known) are the smooth forms which characterise the upper or middle zones of the Chalk.

The right-hand stem and branches are occupied by various specialised forms from the upper and middle zones of the Chalk. *S. bulbiferus* shows a specialisation in the bulbiform character of the extremity of its arms, and *S. bipunctatus* in the character of the spines on the ventro-lateralia. *S. ocellatus* and *S. argus* are specialised in the peculiar nature of their armature. All these forms are spinous, their specialisation lying in other directions.

Genus—HADRANDERASTER.

The majority of the plates on this form are spinous, although a few distal plates are smooth, probably indicating a catagenetic tendency in this direction.

Genus—Pycinaster.

Spines are very feebly developed in this genus. The spine-pits when present are very shallow, and often they are absent altogether. Spine-pits are often visible on the actinal plates after they have disappeared from the abactinal series.

P. crassus possesses rugosities on the distal marginalia.

Genus—Artiiraster.

A. cristatus possesses both spines and rugosities; *A. Dixoni* is rugose without spines.

Speculation as to phylogeny in these latter three genera, in view of the state of our knowledge, would be valueless.

GLOSSARY.

The following glossary and diagram (Text-fig. 34) is added to aid the geologist who has but little acquaintance with modern zoological terms.

Abactinal.—Applied to the surface which is uppermost when the starfish walks on its tube feet; the term "dorsal" is used by some authors in the same sense.

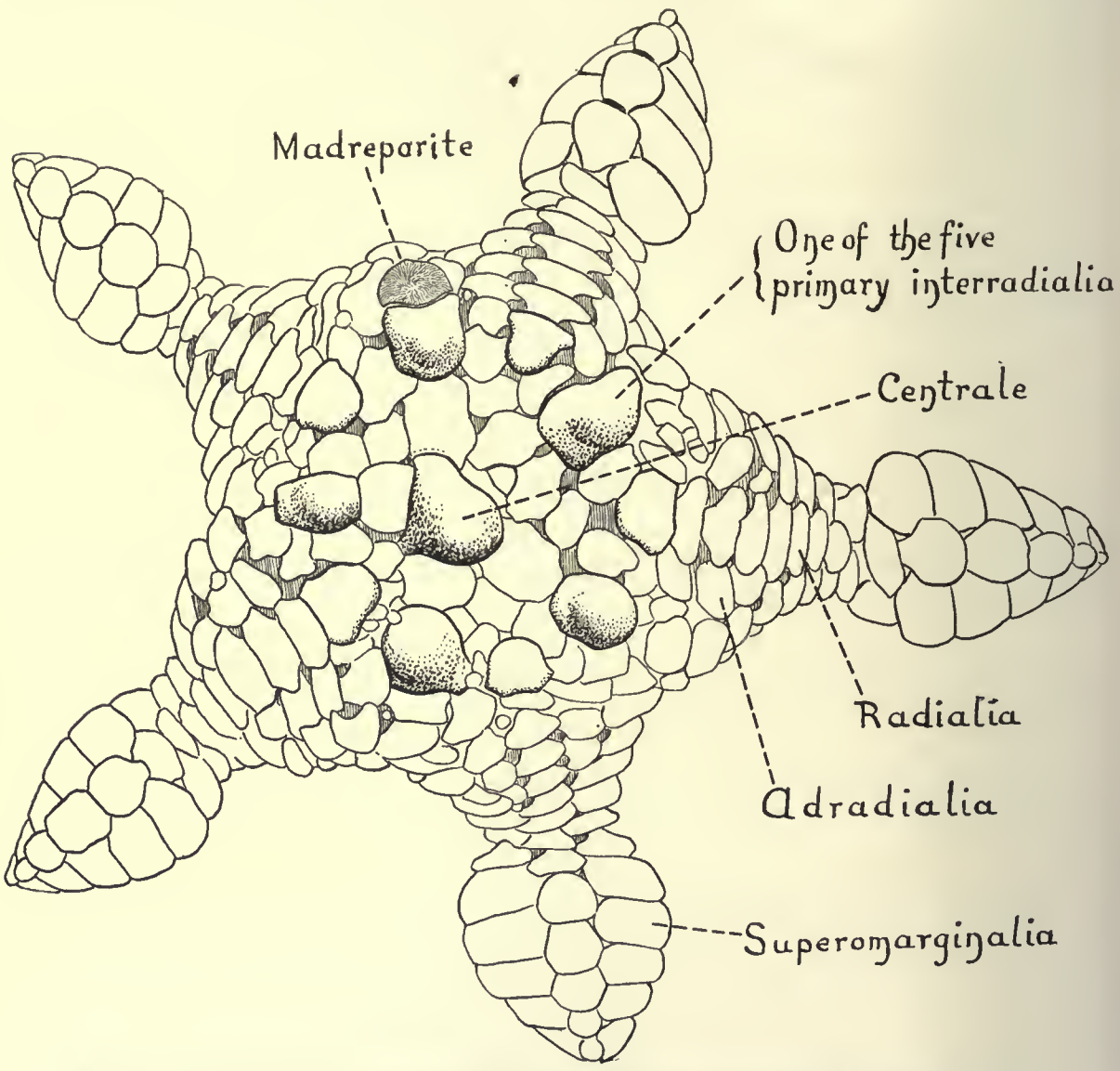
Actinal.—Applied to the surface which is undermost when the starfish walks. On this surface are situated the mouth and the ambulacral grooves. The term is used synonymously with "ventral" by some authors.

Adambulacralia or *Adambulacral Plates.*—The ossicles which are adjacent to the ambulacral ossicles. In the order "Phanerozonia," to which the great majority of Chalk Asteroids belong, these ossicles are visible on the actinal surface, bordering the ambulacral groove and hiding the ambulacral ossicles. Adambulacralia may be recognised by their prominent armature of spines.

Adradialia.—Ossicles situated on either side of the radialia (*q. v.*).

Ambulacral.—The ambulacral groove is the groove stretching from the mouth to the extremities of the arm. It is formed by the ambulacral ossicles, which meet in the middle so as to form an arch. The tube feet project through the arch and into the groove.

Centrale.—The most central ossicle on the abactinal surface of the disc. This ossicle, together with five ossicles situated inter-radially and called the "Primary Inter-radialia," are especially prominent in the young form, in which they often occupy almost the whole of the abactinal surface. Generally speaking



Text-fig. 34.—Abactinal view of a specimen of *Stauranderaster bulbiferus*, natural size, slightly restored from the specimen from Charlton, Kent, registered E. 4344 in the British Museum (Nat. Hist.).

they can be distinguished in the adult form by their larger size, and occasionally they are especially prominent, as in species of *Stauranderaster* (Text-fig. 34) and of the recent genus *Pentaceros*.

Marginalia.—In adult forms of the order "Phanerozonia," which includes

PLATE XXVII.

LINCKIA SP., n. sp. (Page 100.)

From the Lower Chalk.

FIG.

1. Actinal aspect; natural size. (Coll. Brit. Mus., E. 5055.)
   a. Actinal aspect of portion of arm; magnified 4 diameters.

OPHIURA FITCHII, n. sp., *ex Forbes*, MS. (Page 103.)

From the Flint Gravel.

2. Actinal aspect, natural size. (Coll. Norwich Mus.)
   a. Cast of actinal aspect in region of mouth; magnified 4 diameters.
   b. Abactinal aspect; natural size.

OPHIURA SERRATA, *Roemer*. (Page 102.)

From the Upper Chalk.

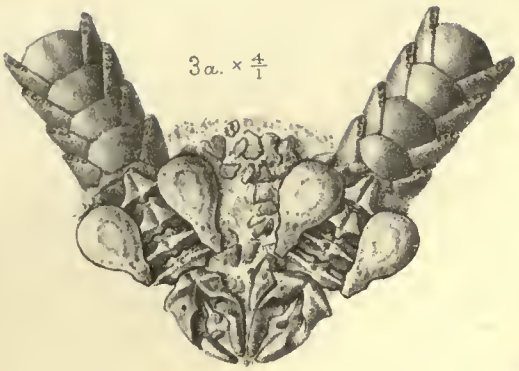
3. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5043.)
   a. Abactinal aspect of segment of disc and two arms; magnified 4 diameters.
   b. Abactinal view of two isolated vertebral ossicles of another specimen; magnified 9 diameters. (Coll. Brit. Mus., E. 5046.)
   c. Side view of the same ossicles; magnified 9 diameters.
   d. Anterior view of the same ossicles; magnified 9 diameters.
   e. Posterior view of the same ossicles; magnified 9 diameters.

OPHIURA PARVISENTUM, n. sp. (Page 103.)

From the Upper Chalk.

4. Abactinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5052.)
   a. Abactinal aspect of portion of one arm; magnified 6 diameters.

3.



3a. × 4/1

1a × 4/1

1.

3c.

× 9/1

3b.

× 9/1

3d. 3e.

× 9/1

2b.

2.

4.

4a. × 6/1

2a × 4/1

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CRETACEOUS ASTEROIDEA.

PLATE XXVIII.

Ophiotitanos tenuis, n. sp. (Page 104.)

From the Lower Chalk.

Fig.

1. Abactinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5056.)
   a. Abactinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).
2. Actinal aspect of another example; natural size. (Coll. Brit. Mus., E. 5057.)
   a. Actinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).

Ophiotitanos lævis, n. sp. (Page 105.)

From the Lower Chalk.

3. Abactinal aspect; natural size. (Coll. Brit. Mus., E. 5053.)
   a. Abactinal aspect of a segment of disc and two arms; magnified 8 diameters (slightly restored).
4. Abactinal aspect of another small example. (Coll. Brit. Mus., E. 5058.)
   a. Abactinal aspect of a segment of disc and one arm; magnified 10 diameters (slightly restored).

Ophiotitanos magnus, n. sp. (Page 106.)

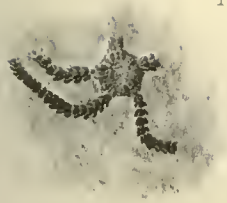
From the Lower Chalk.

5. Actinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5060.)
   a. Actinal aspect of portion of arm; magnified 4 diameters (slightly restored).

Amphiura cretacea, n. sp. (Page 107.)

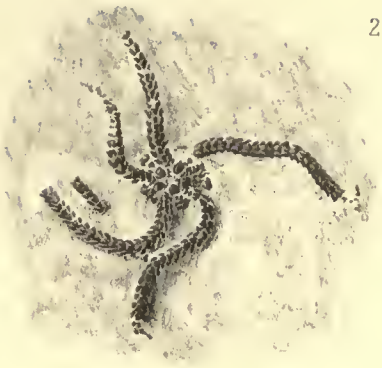
From the Lower Chalk.

6. Actinal aspect of type specimen; natural size. (Coll. Brit. Mus., E. 5059.)
   a. Actinal aspect of a segment of disc and two arms; magnified 10 diameters (slightly restored).



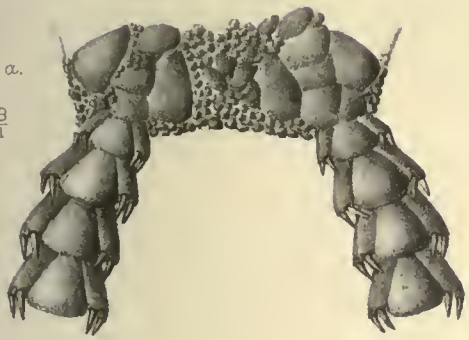
1.

4a. × 10/1

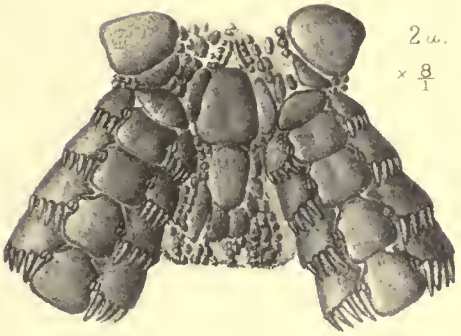


2

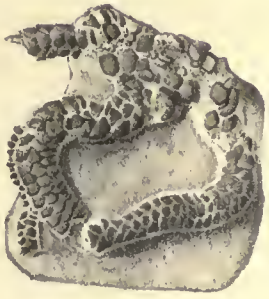
4.



1a. × 8/1



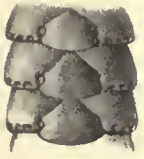
2a. × 8/1



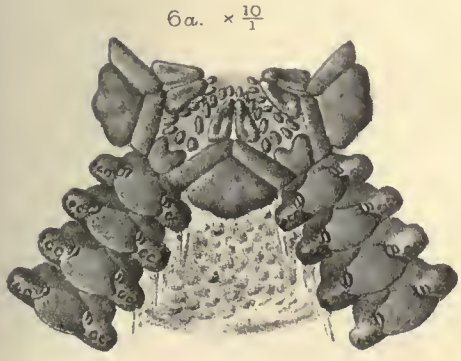
5.

6.

3.



5a. × 4/1



6a. × 10/1

3a. × 8/1

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CRETACEOUS ASTEROIDEA.

PLATE XXIX.

Pycinaster crassus, n. sp. (Page 96.)

From the Upper Chalk.

Fig.

1. Actinal aspect of a small specimen; natural size. (Coll. Brit. Mus., E. 2576.)
2. Abactinal aspect of surface of arm of type specimen; natural size. (Coll. Brit. Mus., 35498.)
   a. Supero-marginal plate; magnified 3 diameters.
3. Supero-marginal plate; natural size. (Coll. Brit. Mus., E. 2631.)
   a. Side view of same ossicle; natural size.
4. Isolated ventro-lateral plate; magnified 2 diameters. (Coll. Brit. Mus., E. 2632.)
   a. Isolated plate from abactinal surface of disc; magnified 2 diameters.
5. Madreporite; natural size. (Coll. Brit. Mus., E. 2628.)

Pycinaster senonensis, *Valette*, sp. (Page 95.)

From the Upper Chalk.

6. Outer view of abactinal ossicle of disc; natural size. (Dr. Blackmore's Collection.)
   a. Side view of same ossicle; natural size.

Nymphaster rugosus, n. sp. (Page 94.)

From the Lower Chalk.

7. Actinal aspect; natural size. (Coll. Brit. Mus., 57516.)
   a. Infero-marginal plate; magnified 6 diameters.

Stauranderaster argus, n. sp. (Page 99.)

From the Upper Chalk.

8. Actinal aspect; natural size. (Dr. Blackmore's Collection.)
   a. One of the ventro-lateral plates; magnified 2 diameters.
9. Inner view of three ossicles isolated from a specimen in the British Museum; figured by Forbes; magnified 2 diameters. E. 2566. [See also Plate XXV, fig. 6.]
   a. Outer view of same ossicles; magnified 2 diameters.

Arthraster cristatus, n. sp. (Page 93.)

From the Upper Chalk.

10. Side view of segment of arm, restored; natural size. (Dr. Blackmore's Collection.)
    a. Outer view of a radiale; magnified 4 diameters.
    b. Side view of same ossicle; magnified 4 diameters.

Arthraster Dixoni, *Forbes*, sp. (Page 91.)

From the Upper Chalk.

11. Ossicle from abactinal surface of disc; natural size. (Coll. Brit. Mus., E. 5024.)
    a. The same ossicle; magnified 3 diameters.

Metopaster cornutus, *Sladen*, sp. (Page 117.)

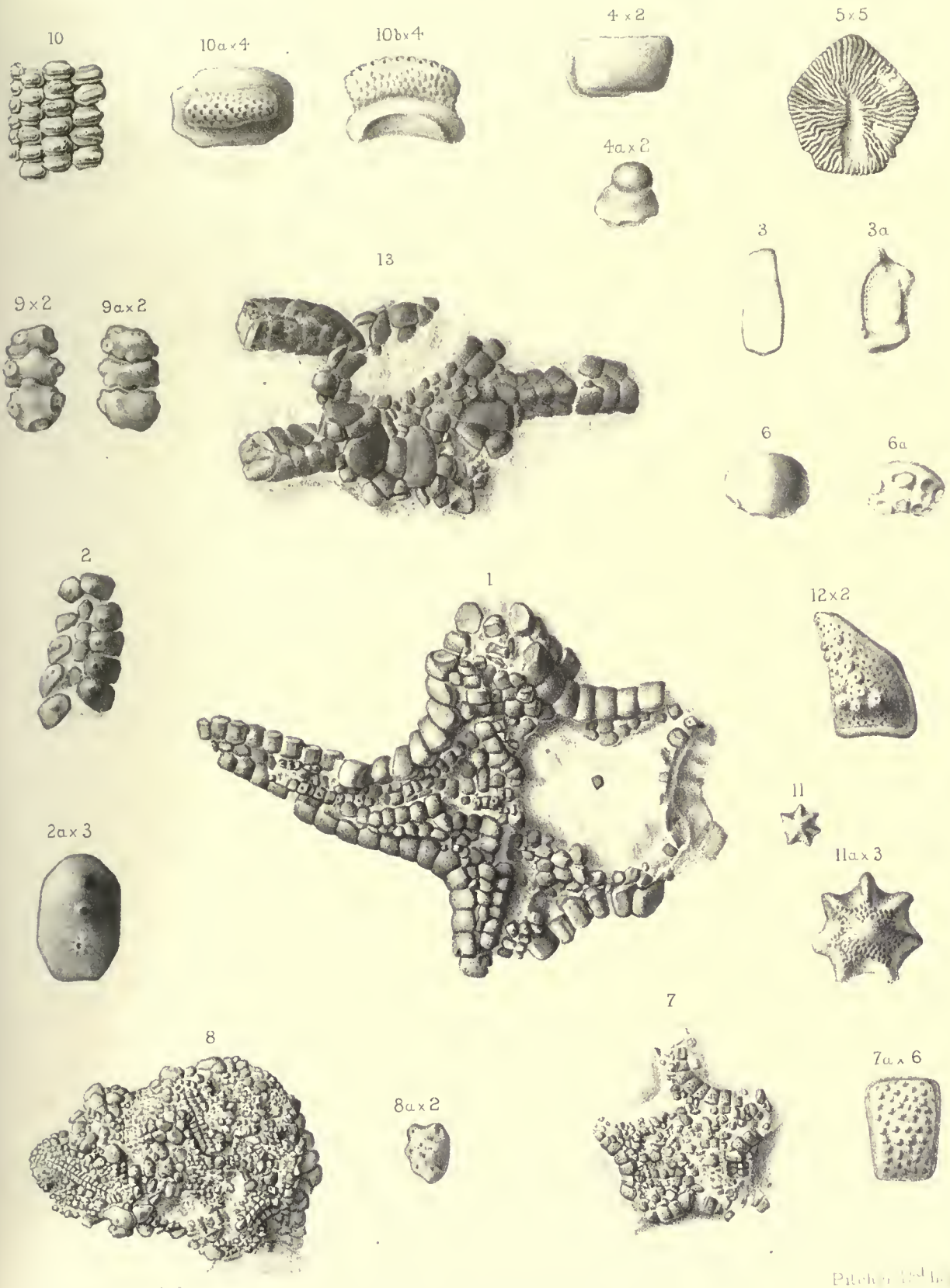
From the Upper Chalk.

12. Ultimate supero-marginal plate of adult specimen; magnified 2 diameters. (Dr. Rowe's Collection.)

Ophiotitanos magnus, n. sp. (Page 106.)

From the Lower Chalk.

13. Abactinal aspect; magnified 2 diameters. (Coll. Sedgwick Mus., Cambridge.)



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CRETACEOUS ASTEROIDEA.

THE BRITISH FOSSIL ECHINODERMATA.

VOL. II, PART V.

Vol 62 303

PAGES 133—138; TITLE-PAGE AND INDEX.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON

MDCCCXCI—MDCCCCVIII.

MONOGRAPH OF THE BRITISH FOSSIL ECHINODERMATA FROM THE CRETACEOUS FORMATIONS.

Vol. II.—Asteroidea and Ophiuroidea.

Mr. Sladen is the author of pages 1—66, Plates I—XVI, while Mr. Spencer is the author of the remainder of the Volume. Mr. Spencer desires to express his indebtedness to Dr. F. A. Bather for much help and advice in his share of the work.

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A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

VOLUME SECOND.

THE ASTEROIDEA AND OPHIUROIDEA.

BY

W. PERCY SLADEN, F.L.S., F.G.S.,

AND

W. K. SPENCER, B.A., F.G.S.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1891—1908.

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Palæontographical Society, 1908.

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PART FIFTH.

Pages 133—138; Title-page and Index.

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almost all Cretaceous Asteroids, and in quite young forms of the order "Cryptozonia," the margin of the disc and arms is bordered by specially prominent plates —the "Marginalia." The abactinal series are called "Supero-marginalia," and the actinal series the "Infero-marginalia."

Primary Inter-radialia.—See *Centrale.*

Radialia.—The abactinal series of plates along a major radius are called the radialia.

Radius.—A line drawn from the central point of the disc to an extremity of the arm is called the "*Major radius*," R. A line drawn from the central point of the disc to a point half-way between two radii is called the "*Minor radius*," r. This is sometimes called an "*Inter-radius.*"

Spine-pits.—Depressions in a plate for the articulation of spines (see p. 113).

Ventro-lateralia.—The plates on the actinal surface of the Asteroid excluding the infero-marginalia and the adambulacralia. In the inter-radial regions these plates are often rhomboidal. A typical view of an isolated plate of this description is given (Pl. XXIX, fig. 4).

ADDENDA ET CORRIGENDA.

Page 24, line 19, for *Schülze* read *C. F. Schulze.*

Page 26, *Locality, etc.*, for *Upper White Chalk near Norwich* read *Hard Chalk, West Norfolk, the precise locality unknown.*

Page 67, line 11, for *Goniaster compactus* read *Goniaster* (*Goniodiscus*) *compactus*, and omit all reference to Forbes, 1848.

Page 69, line 15, for *Stellaster comptoni* read *Goniaster* (*Stellaster*) *Comptoni.*

Page 71, line 4, for *Stellaster elegans* read *Goniaster* (*Stellaster*) *elegans.*

Page 89, line 8 from end, for *Bourguetiocrinus* read *Bourgueticrinus.*

Page 90, last line, for *Upper Greensand* read *Lower Chalk.*

Page 95, line 3, for *Sladen* read *Forbes.*

Page 95, line 13, for (*p. 89*) read (*p. 89, Pl. XXV, fig. 7*).

Page 101, line 9 from end, the first reference should read Ophiura, *Lamarck*, 1801. *Systeme des Animaux sans Vertebrés*, p. 350. The date of the reference given is 1816.

Page 102, line 12, for *1841* read *1840.*

Page 103, line 10, add *cor-anguinum zone, Northfleet, Kent, and Blandford, Dorset.*

Page 103, line 11, add in synonym: Ophiura serrata? *Forbes*, 1843. *Proc. Geol. Soc., vol. iv, p.* 234.

Page 103, line 4 from end, for *parvisentum* read *parvisentis.*

Page 106, line 7, after *E5060* add *and E5061*; under *Locality* insert *Folkestone.*

Page 117, line 12 from end, for *M.* read *Metopaster.*

Page 117, line 7 from end, for *M.* read *Mitraster.*

Page 117, line 2 from end, for *M.* read *Metopaster.*

Page 118, line 3 from top, for *M.* read *Mitraster.*

Page 118, line 7 from top, for *M.* read *Metopaster.*

Page 118, line 9 from top, for *M.* read *Metopaster.*

Page 118, line 12 from top, for *M.* read *Mitraster.*

Page 119, line 3 from end, for *bipunctatus* read *bispinosus.*

Page 120, line 13 from end, for *bipunctatus* read *bispinosus.*

Page 130, table and line 7 from end, for *bipunctatus* read *bispinosus.*

Page 121, lines 2, 4, 6, for *S.* read *Stauranderaster.*

Pl. IV, figs. 2—4, for *Lower* read *Upper.*

Pl. V, fig. 1, for *Tomidaster sulcatus* read *Calliderma Smithiæ* (see p. 123).

Pl. VII, figs. 1 *a* and 2 *a*, for *? Nymphaster Coombii* read *Calliderma Smithiæ* (see p. 122).

Pl. X, fig. 4, for *Metopaster Parkinsoni* read *Metopaster uncatus* (see p. 124).

Pl. XIX, fig. 3, for *Nymphaster Coombii* read *Calliderma Smithiæ* (see p. 122).

Pl. XXI, fig. 2, for *Pentagonaster robustus* read *? a young form of Pycinaster angustatus* (see p. 95).

Pl. XXIV, fig. 1, for *Pentaceros abbreviatus* read *Hadranderaster abbreviatus* (see p. 125).

Pl. XXV, fig. 2, for *Upper Greensand* read *Lower Chalk.*[1]

Pl. XXV, fig. 6, for *Genus? sp.?* (p. 93) read *? Stauranderaster argus* (p. 99).

Pl. XXV, fig. 7, for *Pentaceros? n. sp.* (p. 89) read *Pycinaster angustatus* (pp. 89, 95).

Pl. XXV, fig. 8, for *marginal* read *internal.*

Pl. XXVI, fig. 1, for *Pentaceros punctatus* read *Pycinaster senonensis* (see p. 95).

Pl. XXVI, fig. 4, for *Calliderma mosaicum* read *Pycinaster angustatus* (see p. 95).

Pl. XXVI, fig. 4, for *From the Lower Chalk* read *From the Upper Chalk.*

Pl. XXVII, fig. 3 *b*, for *abactinal* read *actinal* or *adoral.*

Pl. XXVII, fig. 3 *c*, for *side* read *right side.*

[1] Mr. H. Woods informs me that recently he has been able to match the matrix in which this fossil is embedded.

Pl. XXVII for *Ophiura parvisentum* read *Ophiura parvisentis.*

Pl. XXVII, fig. 4, before *natural size* insert *slightly less than.*

Pl. XXIX, fig. 12, for *Sladen sp.* read *Sladen.*

On all Plates (except XXVI) for *Calliderma mosaicum* read *C. Smithiæ* (see p. 122).

On all Plates for *Metopaster Bowerbankii, M. Mantelli, M. zonatus,* read *M. Parkinsoni* (see p. 124).

On all Plates for *Metopaster cingulatus* read *M. uncatus* (see p. 124).

On all Plates for *Pentaceros bulbiferus, P. Boysii, P. coronatus, P. bipunctatus, P. squamatus, P. pistilliferus, P. ocellatus, P. argus,* read *corresponding species of Stauranderaster* (see p. 125).

On all Plates for *Pentagonaster megaloplax,* read *P. quinqueloba* (see p. 108).

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